Errata

Title & Document Type: E1725C and E1740A Time Interval Analyzers Getting Started Guide

Manual Part Number: E1725-90012

Revision Date: April 1, 1998

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

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Getting Started Guide

HP E1725C and HP E1740A Time Interval Analyzers with the HP E1742A/43A/44A/46A/48A Analysis Software

Getting Started Guide

This guide describes how to start using the HP E1725C and the HP E1740A Time Interval Analyzers (TIA) with the HP E1742A, HP E1743A, HP E1744A, HP 1746A, and HP E1748A Analysis Software (HP E1725C options 242, 243, 244, 246, and 248, respectively). Information on installation, start-up, and first use of the TIA are provided.

HP E1725C and HP E1740A Time Interval Analyzers with the HP E1742A/43A/44A/46A/48A Analysis Software

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Printed: April 1998

Printed in USA

Manual part number E1725-90012

Certification and Warranty

Certification

Hewlett-Packard Company certifies that this product met its published specification at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (formerly National Bureau of Standards), to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

Warranty

HP warrants HP hardware, accessories and supplies against defects in materials and workmanship for a period of one year from date of shipment. If HP receives notice of such defects during the warranty period, HP will, at its option, either repair or replace products which prove to be defective. Replacement products may be either new or like-new.

HP warrants that HP software will not fail to execute its programming instructions, for the period specified above, due to defects in material and workmanship when properly installed and used. If HP receives notice of such defects during the warranty period, HP will replace software media which does not execute its programming instructions due to such defects.

For detailed warranty information, see back matter.

Safety Considerations

General

This product and related documentation must be reviewed for familiarization with this safety markings and instructions before operation.

This product is a safety Class I instrument (provided with a protective earth terminal).

Before Applying Power

Verify that the product is set to match the available line voltage and the correct fuse is installed. Refer to instructions in Chapter 1 of the Manual.

Before Cleaning

Disconnect the product from operating power before cleaning.

Safety Earth Ground

An uninterruptible safety earth ground must be provided from the mains power source to the product input wiring terminals or supplied power cable.

Warning Symbols That May Be Used In This Book

Instruction manual symbol; the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual.

Indicates hazardous voltages.

Safety Considerations (contd)

Indicates earth (ground) terminal.

or

Indicates terminal is connected to chassis when such connection is not apparent.

Indicates Alternating current.

Indicates Direct current.

WARNING

BODILY INJURY OR DEATH MAY RESULT FROM FAILURE TO HEED A WARNING. DO NOT PROCEED BEYOND A WARNING SIGN UNTIL THE INDICATED CONDITIONS ARE FULLY UNDERSTOOD AND MET.

CAUTION

Damage to equipment, or incorrect measurement data, may result from failure to heed a caution. Do not proceed beyond a *CAUTION* sign until the indicated conditions are fully understood and met.

For additional safety and acoustic noise information, see back matter.

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7.CD.NL.A.03.11.97.R1.J.CW2F

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In This Guide

This book is the getting started guide for the HP E1725C and HP E1740A Time Interval Analyzers. It consists of a table of contents, this preface, three chapters, and an index.

This preface contains the following information:

- Guide Organization pg. vii
- Description of the High Performance Time Interval Analyzer pg. viii
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Guide Organization

Table of Contents

In This Guide (this preface) introduces you to the getting started guide, and provides general information on the HP E1725C/HP E1740A Time Interval Analyzer (TIA).

Chapter 1, "**How to Begin**," provides complete system requirements and information, and step-by-step instructions on how to assemble and start operating your TIA.

Chapter 2, "**Practice Using the TIA**," provides a short tutorial that teaches you how to set up the TIA to acquire and analyze measurement data without the need for an actual signal to measure.

Chapter 3, "**Demo Waveforms**," provides detailed demonstrations about measuring and analyzing actual signals. Data files are included with your software to be used as examples to illustrate key points.

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Description of the High Performance Time Interval Analyzer

The HP E1725C and HP E1740A Time Interval Analyzers provide new insight into critical timing issues for applications in computer, communications, and defense industries. The HP E1725C TIA features a modular architecture that offers both high performance timing measurements and a customized user-interface, which can be configured to specific measurement applications. The HP E1740A Time Interval Analyzer VXI module is the measurement hardware of the system. The HP E1742A/43A/44A/46A/48A series of analysis software is designed to "tune" the TIA to specific needs for greater ease-of-use and higher productivity. The TIA and software provide the following measurement and analysis features:

- Graphical user interface implemented in Windows® 3.1 or Windows® 95

  A mouse, or similar pointing device, can be used to set up the TIA, control operation, and analyze results.

- Large sequential data capture

  Up to 256 thousand single-channel measurements can be acquired in sequence. This can be useful when studying phenomena which occur over many measurement samples.

- Large histogram capacity

  Large amounts of data can be collected into a histogram very quickly. Statistical analysis is enhanced with higher confidence due to large sample sizes.

- Continuous edge sampling up to 80 MHz rate

  In the HP E1743A and E1744A, every edge can be timed in a pulse series up to an 80 MHz rate (12.5 ns minimum continuous interval, 3.2 µsec maximum interval). In the HP E1742A, HP E1746A, and HP E1748A (and optionally the HP E1743A and HP E1744A), every

edge can be captured up to a 40 MHz rate (25 ns minimum continuous interval, 104 ms maximum interval).

- Easily share data with other applications

  Include TIA results in lab reports using Windows word processing software such as Microsoft Word for Windows or Lotus® Amipro®.

- Resolve signal edge timing to within 50 ps LSD

  Characterize small amounts of jitter and timing noise on a single-shot basis.

Documentation List

The following manuals are part of the standard HP E1725C Time Interval Analyzer:

Manual Title	**HP Part Number**
HP E1725C and HP E1740A Time Interval Analyzers with the HP E1742A/43A/44A/46A/48A Analysis Software Getting Started Guide (this guide)	E1725-90012
HP E1740A Time Interval Analyzer User's Guide	E1740-90005
HP E1421B VXI Mainframe Manual	E1421-90000
HP E1406A Command Module User's Guide	E1406-90004
HP E1406A Command Module Installation Guide	E1406-90027
HP Omnibook 5700 CTX Laptop Computer manuals	_____
National Instruments GPIB User's Manual	_____
MS-DOS® and Windows® 95 manuals	_____

Where to Find Information

The order in which you use these resources will depend on your situation. When first starting to use the HP E1725C or HP E1742A/43A/44A/46A/48A, refer to this Getting Started Guide. When setting up the HP E1740A TIA in a VXI system you will find very important information in the HP E1740A User's Guide.

To find out more about...	**Refer to the following...**
installing the HP E1725C Time Interval Analyzer or HP E1742A/43A/44A/46A/48A Analysis software	HP E1725C and HP E1740A Time Interval Analyzers with the HP E1742/43/44A/46A/48A Analysis Software Getting Started Guide (this guide)
installing the HP E1740A Time Interval Analyzer VXI module	HP E1740A User's Guide
the specifications for the HP E1725C/HP E1740A TIA	HP E1740A User's Guide
how to program the HP E1740A Time Interval Analyzer VXI module	HP E1740A User's Guide
the HP E1421B six-slot mainframe	HP E1421B Mainframe Manual
the portable computer for the HP E1725C	HP Omnibook 5700 CTX Laptop Computer manuals
making specific HP E1742A/43A/44A/46A/48A measurements	HP E174XA on-line Help

1

How to Begin

In this Chapter

This chapter describes in a step-by-step fashion how to assemble and start operating your Hewlett-Packard TIA (Time Interval Analyzer). The steps also make a good checklist to follow when you suspect a problem with your setup.

Components Needed to Configure a TIA	**Components Provided with a Standard HP E1725C**	**Possible Alternatives**
VXI mainframe	6-slot mainframe (included)	13-slot mainframe, such as the HP E1401B
Computer	HP Omnibook 5700 CTX Laptop Computer	HP Vectra or IBM-compatible PC with HP 82335B or HP 82341B HP-IB card installed
VXI interface/control	Included in HP 1406A Slot-0 command module (with HP-IB card in computer)	____
TIA module	HP E1740A (included)	None
Measurement control and analysis software	HP E1742A Tributary Jitter Analysis HP E1743A Clock Jitter Analysis HP E1744A Token Ring Jitter Analysis HP E1746A Network Synchronization Measurement Software HP E1748A Multiple-Channel Network Synchronization Measurement Software (one included)	Create custom programs to control the HP E1740A TIA module.

Components Needed to Configure a TIA	Components Provided with a Standard HP E1725C	Possible Alternatives
MS-DOS 6.0 (or later)	(included)	MS-DOS 5.0 (or later)
Windows® 3.1 or Windows® 95	Windows® 95	____
National Instruments PCMCIA-GPIB Kit	(included)	None

HP E1725C and HP E1740A Time Interval Analyzers with the HP E1742A/43A/44A/46A/48A Analysis Software

The HP E1725C TIA is a stand-alone instrument. Connect the pieces as described below and apply power. Skip the steps that do not apply. The TIA is then ready to start measuring.

The HP E1742A/43A/44A/46A/48A are options to the HP E1725C (option 242, 243, 244, 246 and 248, respectively). These software packages are Microsoft Windows applications, which serve as the user interface and analysis portion of the TIA. At least one of these packages must be included with the HP E1725C.

This guide describes how to assemble the TIA and start using it. If you are assembling the HP E1725C for the first time, reassembling it after some time, or building the TIA using other computers or VXI mainframes, this procedure will help.

The standard HP E1725C TIA instrument consists of the following items:

- HP E1740A Time Interval Analyzer (two-slot, C-size VXI module)
- HP E1406A Slot-0 Command Module (one-slot, C-size VXI module)
- HP E1742A/43A/44A/46A/48A Analysis Software
- HP Omnibook 5700 CTX Laptop Computer
- Six-slot VXI C-size mainframe
- National Instruments PCMCIA-GPIB Kit (includes a PCMCIA card and a GPIB cable)
- DOS and Windows software
- Four oscilloscope probes (three 10:1 and one 1:1)
- Blank panels for covering unused VXI mainframe slots

Assembling the TIA

HP E1725C TIA Assembly

This section assumes that the HP E1725C is completely disassembled. Just skip the steps that do not apply to your situation. The intention is to meet your needs if in the future you need to rebuild an HP E1725C that has been disassembled. **The standard HP E1725C is shipped from the factory assembled and configured**.

1 Before you start, make sure power is shut off to all of the components.

2 Install the HP E1406A Command Module in slot 0 of the VXI mainframe. (With the standard HP E1725C 6-slot mainframe, this will be the slot at the bottom or left side, depending on the orientation of the mainframe.)

Line up the module with the slot guides and then press the module firmly into the backplane connectors. Tighten the screws attached to the command module to fully seat the module into the backplane connectors of the mainframe.

3 Install the HP E1740A TIA module in slots 1 and 2 of the VXI mainframe or any other open slots.

NOTE

Always check that the mainframe power is OFF before installing any boards or instruments into the backplane connectors. This is also a good time to check that the TIA module address setting is unique and different from other modules already installed in the mainframe. The HP E1740A address (ULA) is set to 48 at the factory, corresponding to a secondary address of 06 when using the HP 82335A/B HP-IB Interface Card. If you are installing multiple TIAs, make sure each one has its own unique address. See the HP E1740A TIA User's Guide for more information about address switch settings.

4 Line up the module with the slot guides and then press the module firmly into the backplane connectors. Use the screws attached to the module to securely tighten down the module.

5 Install blank panels over any unused slots of the VXI mainframe to help maintain proper cooling of VXI modules.

6 Apply power to the laptop computer and the VXI mainframe.

Installing the HP E1742A/43A/44A/46A/48A Analysis Software

This section provides instructions for installing the user-interface software onto your computer. This software is already installed on the HP E1725C TIA. If you have purchased the HP E1742A/43A/44A/46A/48A Analysis Software by itself, follow these instructions to install the software.

HP E1725C TIA Requirements

The following are the minimum requirements to support operation of the HP E1725C TIA using the HP E1742A/43A/44A/46A/48A software.

- 20 MHz 386-based PC with a 387 co-processor
- 8 megabytes of RAM
- A hard disk with at least 6 megabytes of free disk space
- DOS version 5.0 (or later) and Microsoft Windows® version 3.1 (or Windows® 95)
- A two-button mouse

It is recommended that you always read any “readme” files associated with the software before proceeding with the installation. These files contain important information which may not be found elsewhere. The HP E174XA readme file can be viewed by one of the following methods:

- Insert the HP E174XA disk 1 in drive **a:** (or whatever floppy drive is appropriate). Start Windows 95, select Programs group, double-click on Windows Explorer icon, choose drive **a:**, and double-click on the “readme.wri” file.
- If the HP E174XA software is already installed on the PC, double-click on the “readme” icon in the HP Applications program group.

Install the HP TIA Software

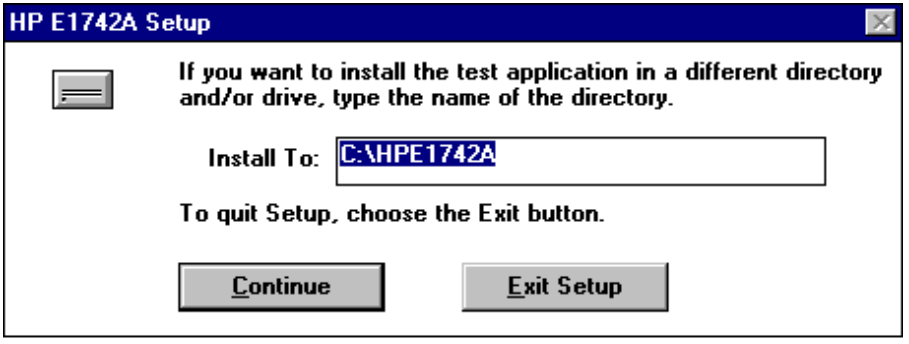
1. Insert the HP E1742A/43A/44A/46A/48A disk 1 into the 3.5-inch floppy drive.
2. Start Windows.
3. Open Windows Explorer and double-click on Setup File to install the software.

NOTE

The software cannot be installed while another Visual Basic program is open in Windows. If you see an error message to this effect, close all other Visual Basic programs to proceed with the installation.

Shortly after double-clicking, you will see the installation window shown below. If you see a different window, you may have inserted disk 3 by mistake. (Disk 3 also has a file with the name setup.exe.) Click **Cancel** and return to step 1.

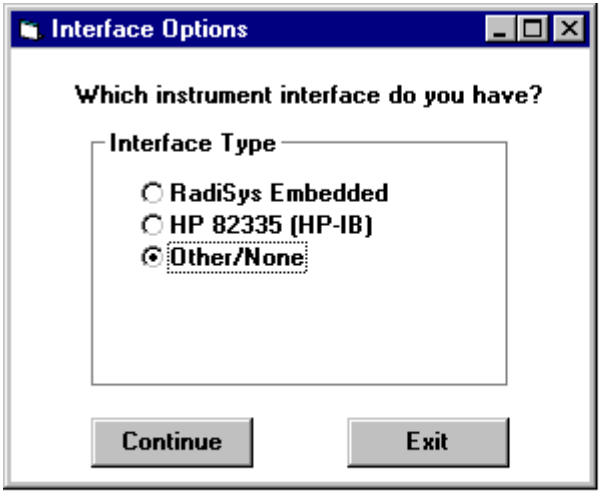
This window allows you to modify the directory for the software installation, or to cancel the installation completely. To cancel the installation, click **Exit Setup** or press **ALT E**.



To Modify the Directory

The default directory is **C:\hpe174Xa** (where X=2, 3, 4, 6, or 8 depending on the particular software package you have). If you want to install the application software files in a different directory, highlight **hpe174Xa** and type in the preferred directory name. Highlight the **C:** if you wish to modify the drive location as well. **Make a note of the directory you have selected as you will need this information later during the installation**. Click the **Continue** button to continue the installation.

An Interface Options window will appear next. If you are using an HP 82335A HP-IB interface, the appropriate Window's driver (**hpib.dll** for the HP 82335A) will be installed for you. If you are certain that the correct interface driver is already available on your system (and in the "path"), you may leave "Other/None" selected. Otherwise, choose the appropriate interface. If the interface you are using is not listed, select "Other/None". Click **Continue** to start the actual installation.



After the program files from disks 1 and 2 are copied to your disk, you will be asked to insert disk 3 into the floppy drive. Insert disk 3 into the floppy drive and click **Continue**. A new setup program will be launched to install the Help system. You will see another "Initializing Setup..." message, and then the opening screen for installing the Help system. Follow the instructions on the screen.

When you are asked to select a directory to install the Help system files (***not*** the shared files to be placed in the Windows System directory), enter the ***same*** directory you noted previously.

When the installation is complete, click the **OK** button. A new program group "HP Applications" will be created. The HP E174XA software, a "read-me" file and the Help icon will be placed in this program group.

Be sure to send in your registration card. This will ensure that you are notified about software updates and other important product information.

Power-Up and Health Check

Start

1 Switch on the VXI mainframe before the computer.

2 Switch on the computer.

Start the HP TIA Software

1 Double-click the **HP Applications** Program Group icon in Windows to open the group.

2 Double-click the **HP E174XA** icon to start the application.

Verify Communication with the TIA

The default interface setting for the HP E1742A/43A/44A/46A/48A is "none."

Set the Interface Type

If this is the first time you have started the software, or if no interface has been previously selected, you will be asked if you wish to select the interface now. Click **Yes** and continue with step 3. Otherwise, select the interface with the following steps:

1 Select **Setup>Instrument Setup**... .

2 The HP E1740A setup window will appear. Click on the **Interface Setup**... button in the lower right hand corner of the window.

3 Select the appropriate interface and addressing. Refer to the on-line Help under the topic of "Interface" and the corresponding documentation that came with the interface. Refer to the HP E1740A User's Guide for details on address switch settings.

4 Click on **OK** once the setting is chosen.

Verify Communication

A convenient way to test the interface with the TIA is to check for an error condition in the HP E1740A. This is a fairly comprehensive test as it requires that the interface is configured correctly and that the hardware is operational.

1 Select **Setup>Instrument Setup**... .

2 Beneath "Calibration & Errors:" (bottom, center of the HP E1740A Setup window), click on the **Service** button.

3 Click on the **Get Error** button in the bottom right corner of the "Calibration and Service" window.

4 If the interface is configured correctly, and there are no hardware error conditions, a small dialog box will appear with the message:

System error code:
+0, "No error"

5 Click on the **OK** button to exit this window. **Close** the Calibration and Service window, and **Cancel** the HP E1740A Setup window to return to the application.

If you do not see the above error-free condition, check that the correct interface has been configured in the HP E1740A Setup window and that the HP E1740A has a unique address (ULA). For HP E1740A hardware error conditions, refer to the HP E1740A User's Guide.

6 You can configure the HP E174XA to always use the interface you just selected as follows:

Select **File>Save Setup As**... .

Select the file **inisetup.stp** in the **c:\hpe174Xa** directory. This is the setup file the software uses as its configuration when loaded.

Where to Now?

If this is your first time using the TIA, you may want to follow the short tutorial in Chapter 2. It demonstrates how to set up the TIA to acquire and analyze measurement data without the need for an actual signal to measure.

Chapter 3 goes into more detail about measuring and analyzing actual signals. Data files are included with your software to be used as examples to illustrate key points. These data files are “generic” and may not illustrate the specific application for which you purchased the software. The on-line Help file is intended to do this.

2

Practice Using the TIA

In this Chapter

This chapter provides the opportunity for you to learn about some of the TIA's features and operation without the need for connecting actual signals to the instrument. Data files which were measured with the TIA are included with the analysis software. A frequency deviation measurement for a frequency modulated (FM) carrier is recalled in these examples to illustrate specific features and capabilities. This chapter covers the general steps to configure the TIA to capture this data as well as steps to follow to analyze the collected data.

The following items are demonstrated in this chapter:

- Presetting the instrument to a known default state
- Recalling a data file and setup (File Menu)
- How to configure the TIA for a measurement (Setup Menu)
- How to initiate a measurement and view the results (Measure and View Menus)
- Using the cursors and zooming
- Printing results

This Getting Started Guide covers features and functions available in the following software applications:

- HP E1742A SONET/SDH Tributary Jitter Analyzer
- HP E1743A Clock Jitter Analyzer
- HP E1744A Token Ring Jitter Analyzer
- HP E1746A Network Synchronization Measurement Software
- HP E1748A Multiple-Channel Network Synchronization Measurement Software

In this Chapter

Each of the above products has functionality specific to a given application, which may not be explicitly covered in this tutorial. Refer to the on-line help in each software package for application-specific information. All features and functions covered in this guide are included in each of these products.

Conventions Used in the Tutorial

Selecting Commands with the Mouse

You select commands by pointing with the mouse cursor and then clicking on each of the commands by pressing the left mouse button. For example, when you see, **Setup>Instrument Setup**..., click on the **Setup** menu and then the **Instrument Setup**... selection in the pulldown menu.

Hints Provided in Italics

Helpful information is presented throughout this tutorial. The information will help you with the current task or sometimes it is just to let you know that you are progressing properly.

TIA Tutorial

You should already have the HP E1742A/43A/44/46A/48A application running. If not, refer to Chapter 1 of this guide for information on how to install the software and start the TIA application.

NOTE

The windows and dialog boxes shown in this guide are those of the HP E1742A. The screens on the HP E1743A/44A/46A/48A may have a slightly different appearance.

Presetting the Instrument to a Known State

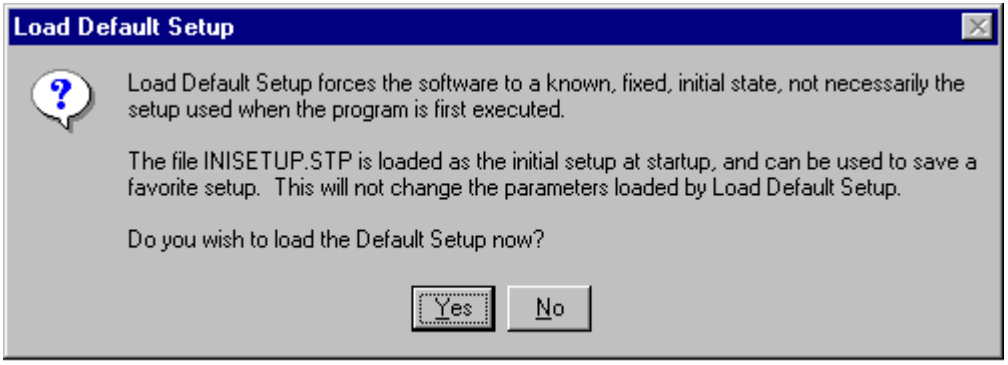
1 Once the TIA application is started, select **File>Load Default Setup**.

The default setup will configure the TIA to a known state as determined by a set of parameters fixed at the factory, similar to the “preset” key on many instruments.

You may also customize the initial user-interface configuration by first configuring the instrument as desired and saving the setup in the file “INISETUP.STP” (**File>Save Setup (inisetup.stp)**). This configuration will automatically be loaded when the Windows application is started. In general, instrument setups are saved by selecting **File>Save Setup As**.

Note that the INISETUP.STP file and the default parameters are two different files, and may not necessarily result in the same instrument configuration.

2 A window will appear with an explanation similar to the one shown here when you retrieve the default setup.



Click on the **Yes** button to proceed.

Recalling a Saved Data File and Setup

1 Select **File>Load Data File**... .

Select the file “fm.pan” in the **c:\hpe174Xa\demo** directory.

You will be using data that was acquired with the TIA and saved as a data file (*.pan). This is a convenient way to experiment with the measurement and analysis features without the need for live input signals.

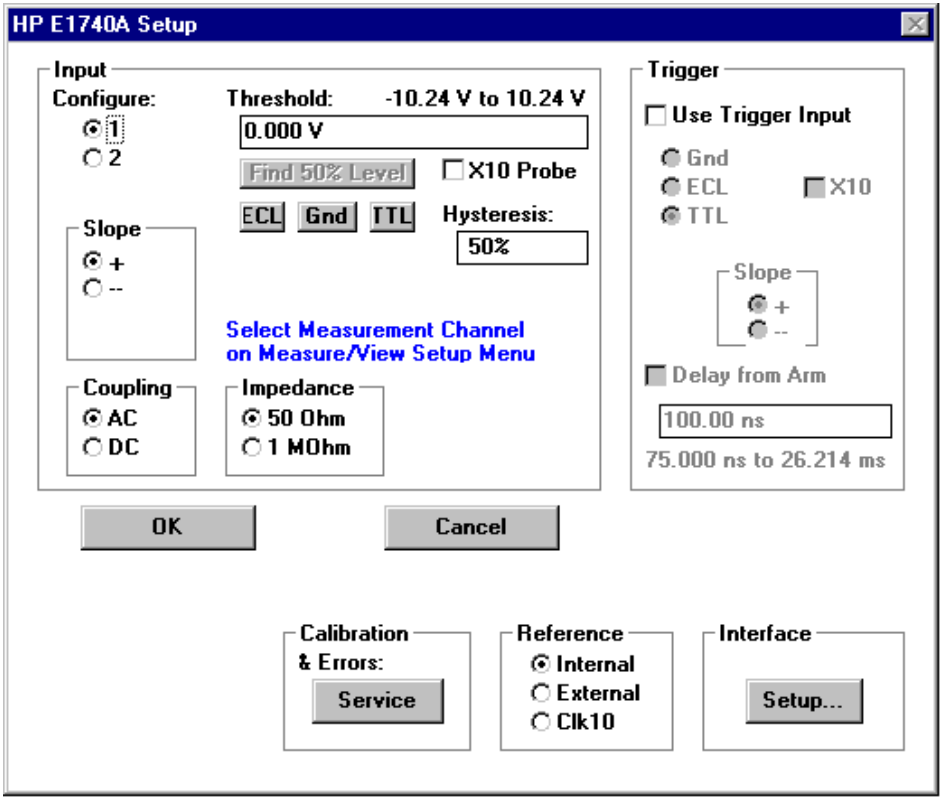
2 Select **File>Load Setup**... .

Select the setup file “fm.stp” in the **c:\hpe174Xa\demo** directory.

This is the instrument configuration used to acquire the data in “fm.pan.”

Configuring the TIA for a Measurement (Setup Menu)

1 Select the Instrument Setup window by clicking on **Setup>Instrument Setup**... .



This window is used to specify the measurement hardware configuration. The window is divided into five or six separate areas. **Input Configure**, **Trigger**, **Calibration & Errors**, **Reference**, and **Interface** are common to all HP E174XA products. You will only need to modify the **Input Configure** and **Trigger** selections for most measurements. In most cases, changes become effective when you click the OK button and close this dialog box.

Input Configure:

Channels 1 and 2 are configured separately by clicking on the appropriate channel. You can determine the input threshold in volts, the threshold slope, the input coupling, and the input impedance. In the HP E1743A/44A/46A/48A, input channel routing is also selected in this area. All of these selections are modified in the HP E1740A immediately.

This menu configures the measurement hardware parameters. To select the channel used to acquire measurements, select ***Setup>Measure/View Setup****.*

Trigger:

You can select whether the TIA will wait for a threshold crossing on the trigger input before acquiring time stamp information. The threshold choices are GND (0 volts), ECL (–1.3 volts) and TTL (1.4 volts). Selecting 10:1 divides these threshold values by 10 if you are using a 10:1 oscilloscope probe on the trigger input.

You may also select a time delay from the trigger edge prior to the acquisition of data. The selectable range of delay is 75 ns to 26.214 ms.

Calibration & Errors:

Clicking on the "Service" button lets you perform a variety of calibration tests on the HP E1740A. Further information on the calibration procedures can be found in the HP E1740A User's Guide.

The Calibration and Service window also provides a "Get Error" button. If for any reason the HP E1740A front panel "Error" LED (red) is illuminated, you can query the HP E1740A for the type of error. This also clears the error condition on the instrument. The error type will be displayed.

Click the ***Close*** *button to return to the HP E1740A Setup menu.*

Reference:

You can choose between three sources for the 10 MHz reference clock for the HP E1740A:

- *Internal: clock reference provided by the HP E1740A internal circuitry.*
- *External: clock reference provided by the user via the input connector on the front panel of the HP E1740A.*
- *CLK10: clock reference provided by the VXI Slot 0 Controller via the VXI backplane.*

Interface

HP E1742A/43A/43A/46A/48A supports various interfaces. Clicking on the ***Setup****... button allows you to select and configure the interface.*

The interface configuration is not affected by recalling the Default Setup Parameters.

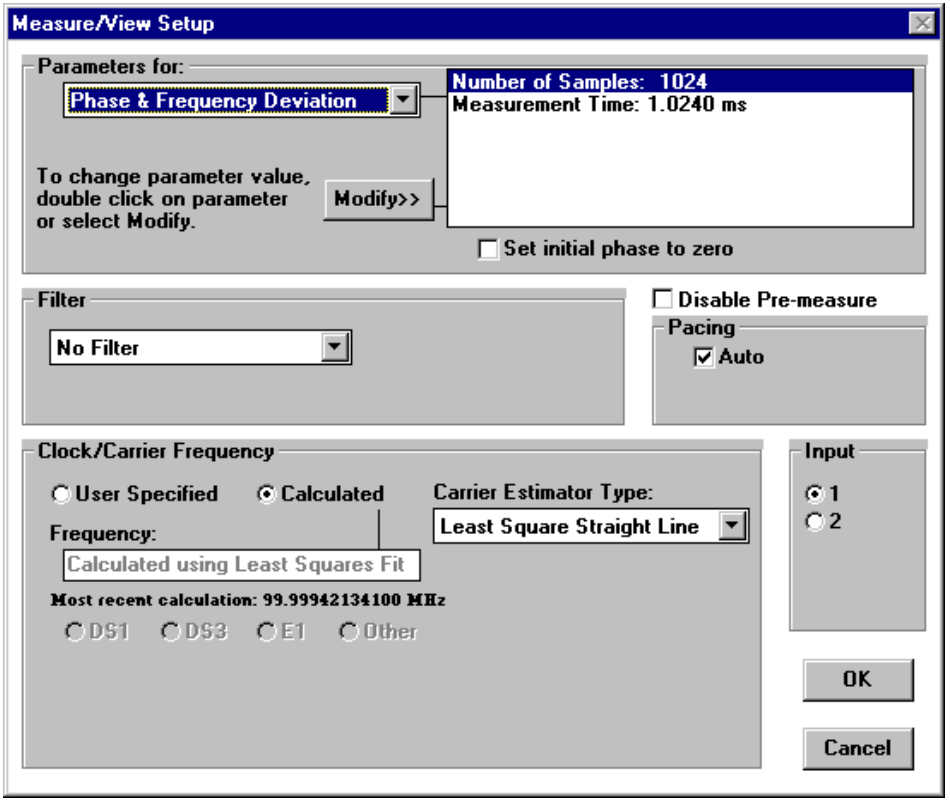
One additional area on the Instrument Setup dialog box appears if you are using the HP E1743A/44A:

Sample Rate

The Sample Rate parameter controls the maximum rate at which the signal can be sampled. It does not control the rate at which the signal is actually sampled. See the HP E1743A/44A on-line Help for more information about Sample Rate.

2 Click on **Cancel** to close the HP E1740A Interface window.

3 Select the measurement setup window by clicking on **Setup>Measure/View Setup**... .



This window is used to specify the measurement processing parameters which are inherent in measurement calculations, such as the number of measurements, the duration of the measurement, the number of averages, filtering, clock/carrier determination, etc. You will also select the TIA input channel (1 or 2) which will be used to collect the data for measurement computations. The actual data acquisition and processing will be selected and initiated from the **Measure** menu. (The HP E1743A/44A/46A/48A dialog boxes will look slightly different than the HP E1742A shown above.)

Parameters for:

This portion of the window lets you modify parameters that are inherent in the measurement processing, such as the measurement time, the number of measurement points during that time, window types for FFT computations, etc.

Next to "Phase & Frequency Deviation," (or "Period, Frequency, TI, & Phase" in the HP E1743A/44A) you will see that you can modify the number of frequency measurements or points to be displayed, and the time duration of the measurement. In general, the "gate time" for each frequency measurement is the measurement time divided by the number of samples. Note however, that the measurement gate is synchronized to the input signal and the actual measurement time may differ from the value entered here.

You can modify each of these parameters by either double-clicking on the desired item, or clicking on the desired item and clicking the ***Modify>>*** *button. Other measurement types are available with their own sets of parameters to configure.*

Filter

You may select a filter type (low pass, high pass, band pass, or smoothing function) to be applied to the measurement results. If either the low pass, band pass, or high pass filters are selected, you can also enter the cut-off frequencies.

Clock/Carrier Frequency

Deviation measurements (phase deviation, frequency deviation, time deviation, etc.) require a reference carrier or clock to compute the relative measurement. This portion of this window lets you enter the frequency of the reference clock directly, or have the HP E1742A/43A/44A/46A/48A estimate the reference frequency for you based upon the acquired data. Various carrier estimation algorithms are also available, depending on the type of signal and modulation you want to measure.

Pacing

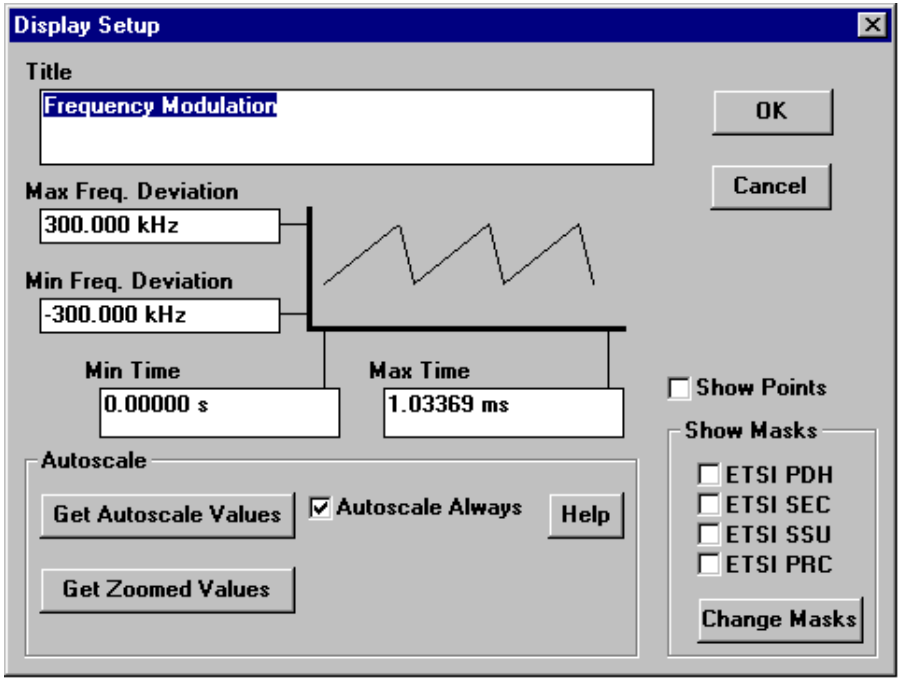
In general, the TIA does not have to time stamp every zero crossing of the input signal to reconstruct the modulation or jitter on the signal. Selection of ***Auto*** *pacing allows the HP E174XA software to determine the number of skipped zero crossings in order to capture the specified number of samples in a given measurement time (as specified in the* ***Parameters for:*** *field). You can directly specify the pacing by "unchecking" the auto box, and entering the pacing value directly.*

Input

Allows selection of the measurement channel to be used for data acquisition and processing. The threshold parameters for each channel are configured in the ***Setup>Instrument Setup****... menu.*

4 Click the **Cancel** button to close this window without making any changes.

5 Select the Display Setup window by clicking on **Setup>Display Setup**... .



The Display Setup menu lets you annotate the display with a title, date, or other descriptive information which may be useful if you store the data to a file or print a hard copy. You can also set the scaling for both the x and y axis of the measurement display or select the **Autoscale** function. Display masks can also be turned on in the Display Setup dialog box. Search the HP E1742A/46A/48A on-line Help for **Show Masks** to obtain more information.

To annotate or title the display, simply click in the box beneath **Title** and enter the descriptive text. For saved data files, the date the file is stored is automatically appended to the title information.

To modify the X or Y scaling, highlight the number of interest and enter the new value. If you don't know these values, click **Get Autoscale Values** and the software will determine them for you.

If you click on the Show Points box, each measurement point will be displayed with a "+" on the waveform presentation, and these points are connected with a line.

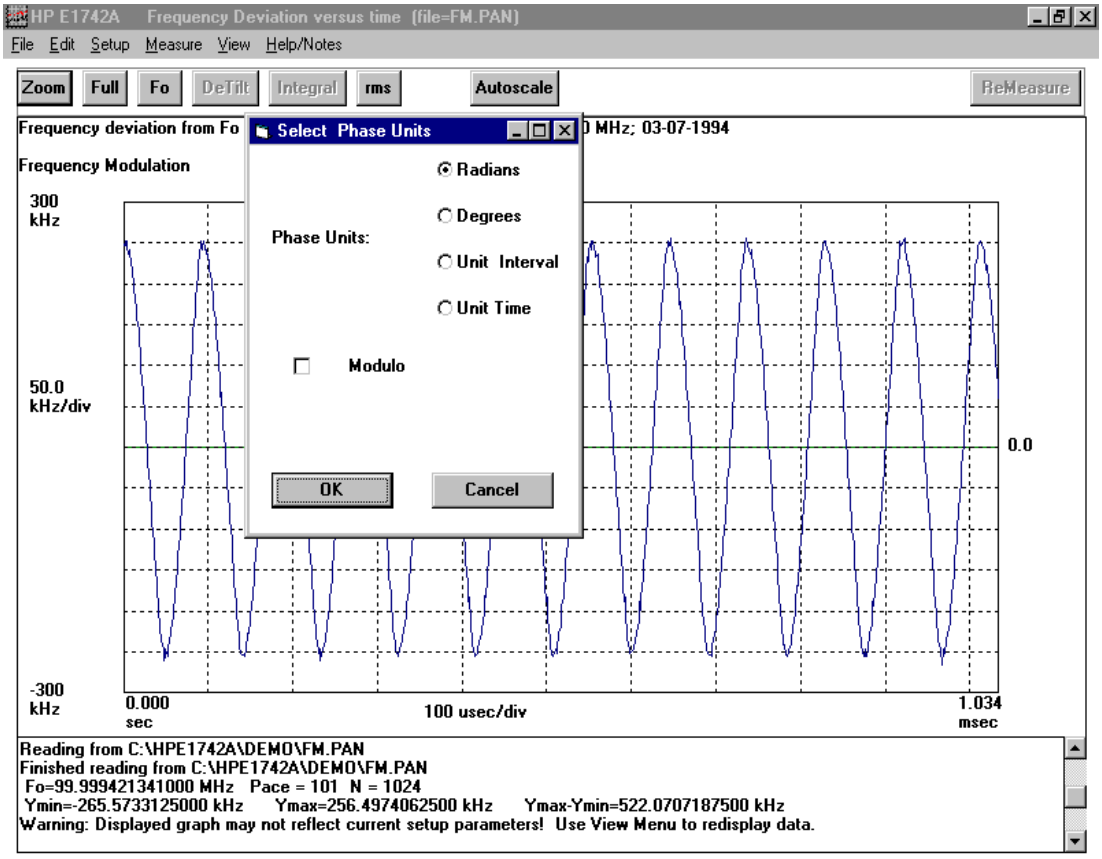
Autoscale

*Click on the **Autoscale Always** box to autoscale both the X and Y axis to the acquired data with each new data acquisition.*

*The **Get Autoscale Values** button provides a convenient way to recall the X and Y axis scale values. This is useful if you modify these values, and then want to return to the autoscale configuration.*

6 Click the **Cancel** button to exit the window without making changes.

7 Select the format for measurement units by selecting **Setup>Phase Units**.

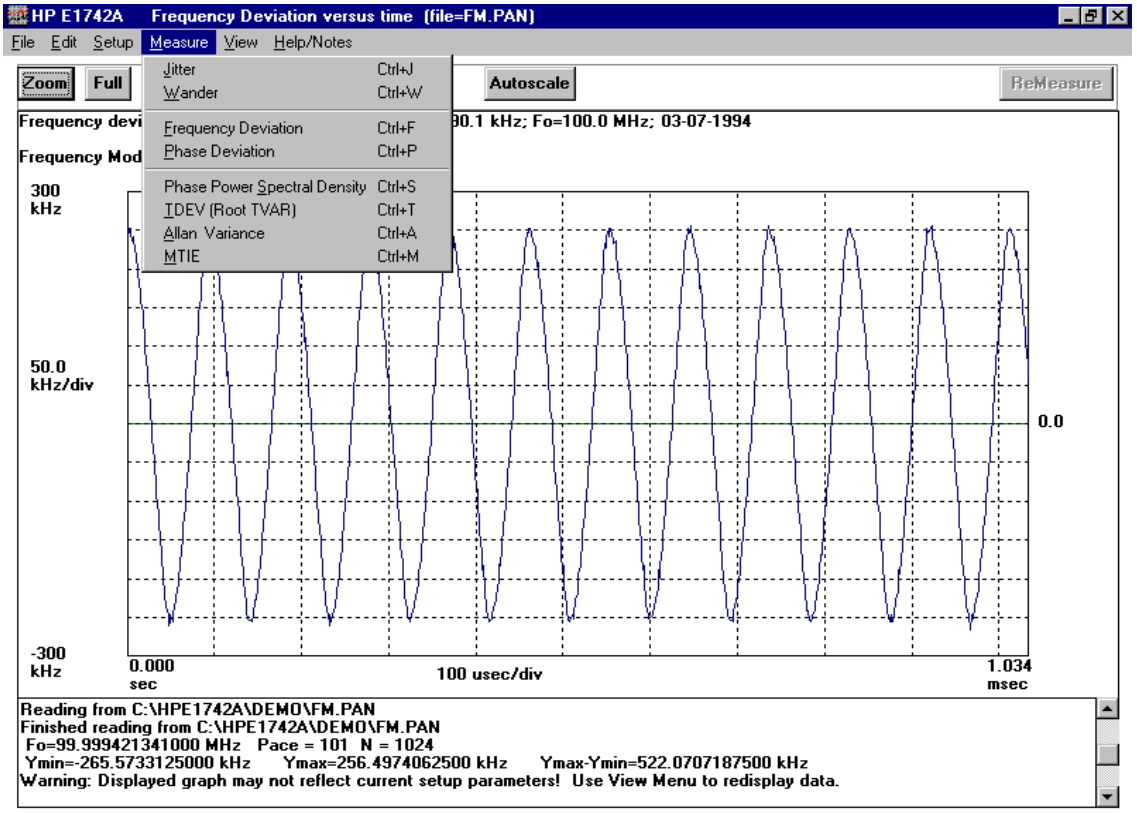


You can select units for the phase measurement results from this window. All phase displays will show the selected units on the Y axis. You can obtain other phase units by clicking on a point. The other units for that point will be shown in the Log display at the bottom of the screen.

Initiating a Measurement and Viewing Results (Measure Menu)

1 Click on **Measure** to view the available measurement selections. Since this demonstration is using a saved data file, **do not select any of the measurement choices at this time**.

If you wanted to make a "live" measurement with hardware, you would select a choice on the **Measure** menu at this time. For example, to measure the dynamic frequency characteristics (FM) of this signal you would select **Frequency Deviation** from the list you see. Subsequent measurement acquisitions can be initiated by clicking on the **ReMeasure** button.



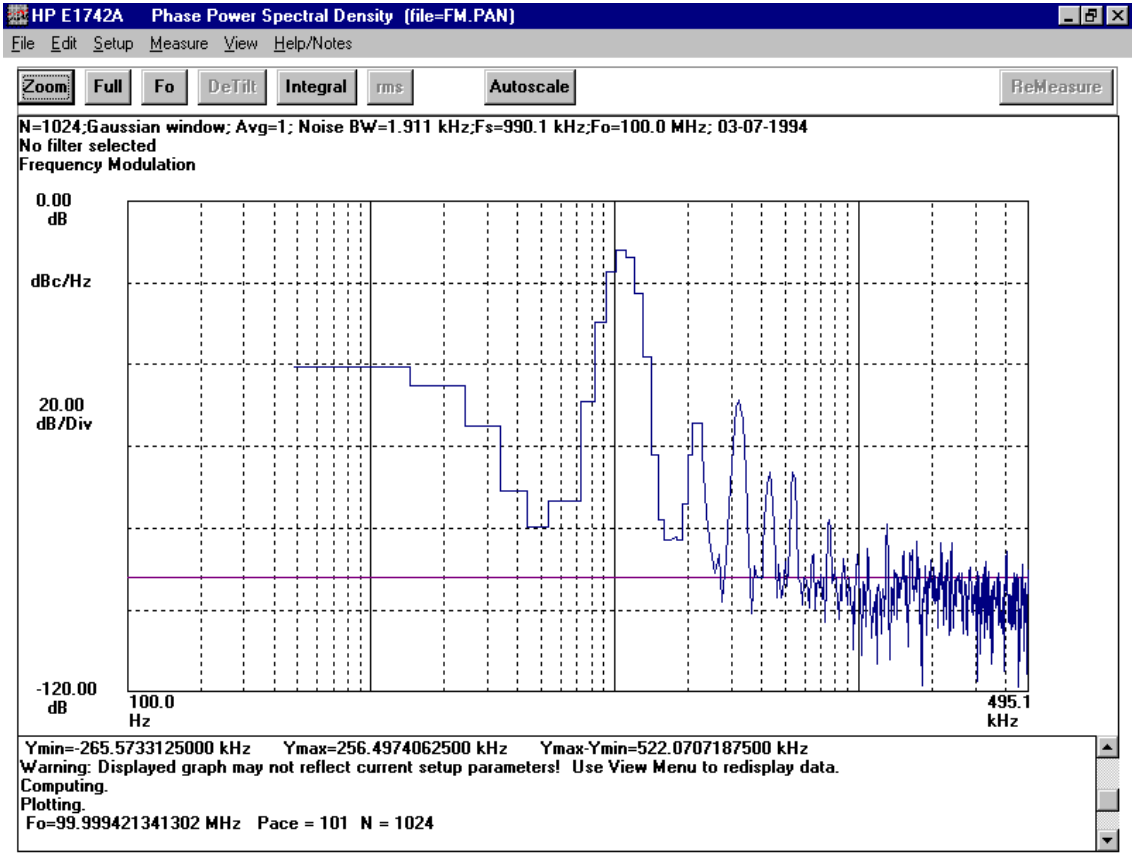
MEASURE MENU VS VIEW MENU. The choices on these two menus are very similar, however the action performed by the instrument is quite different. Selecting any of the choices on the **Measure** menu will cause the instrument to initiate a measurement and acquire a new set of data points and perform the selected result processing. Selecting any of the choices on the **View** menu will cause the instrument to perform the selected calculations *on the currently acquired data*.

The notable difference between the selections on the Measure and View menus is that the View menu also offers the choice to compute an FFT of the data currently on the display.

Note that data files that are saved and subsequently recalled can be "re-processed" to compute other results using the **View** menu.

The display is now showing Frequency vs. time. This signal is a 100 MHz carrier with sinusoidal frequency modulation (approximately a 11 kHz rate and a 500 kHz p-p deviation). You can re-process the data to display phase power spectral density by performing the following step.

2 Select **View>Phase Power Spectral Density**.

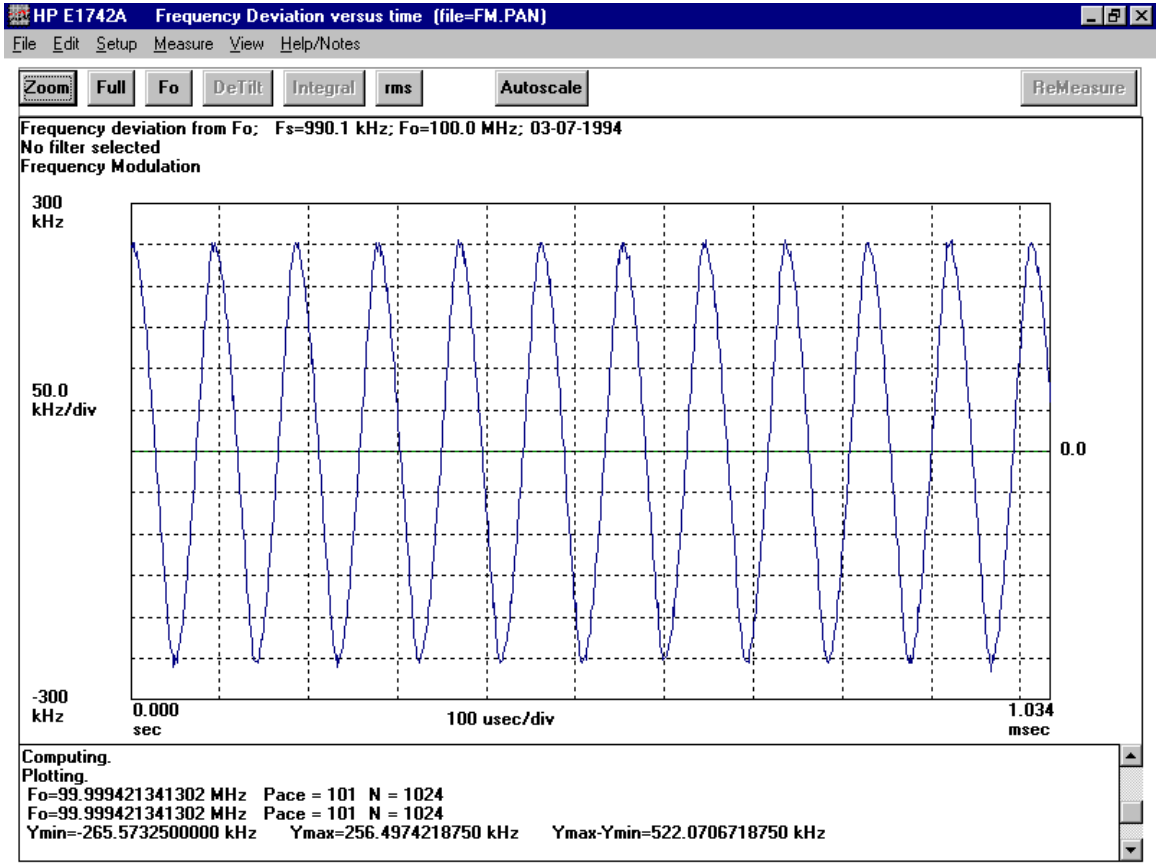


This display was computed from the “fm.pan” data. This is the power spectral density plot of the modulating tone. The 11 kHz modulation is easily seen on this display, as well as other modulation products.

Using Cursors, Markers and Zooming

1 Select **View>Frequency Deviation**.

The results display is divided into two primary areas. The major portion of the display is devoted to the graph of measurement results, in this case frequency deviation vs. time. The very top of this area includes a description of the measurement function and the key processing parameters that apply to the processing and the date the measurement was taken. As shown in this example:



"Frequency deviation from Fo as function of time. Fs=9.901 kHz; Fo=100 MHz; 03/07/1994"

Where:

Fs = sampling frequency or the nominal measurement gate time for each data point.

Fo = clock or carrier frequency used in the deviation calculations.

The date is the date the measurement was taken.

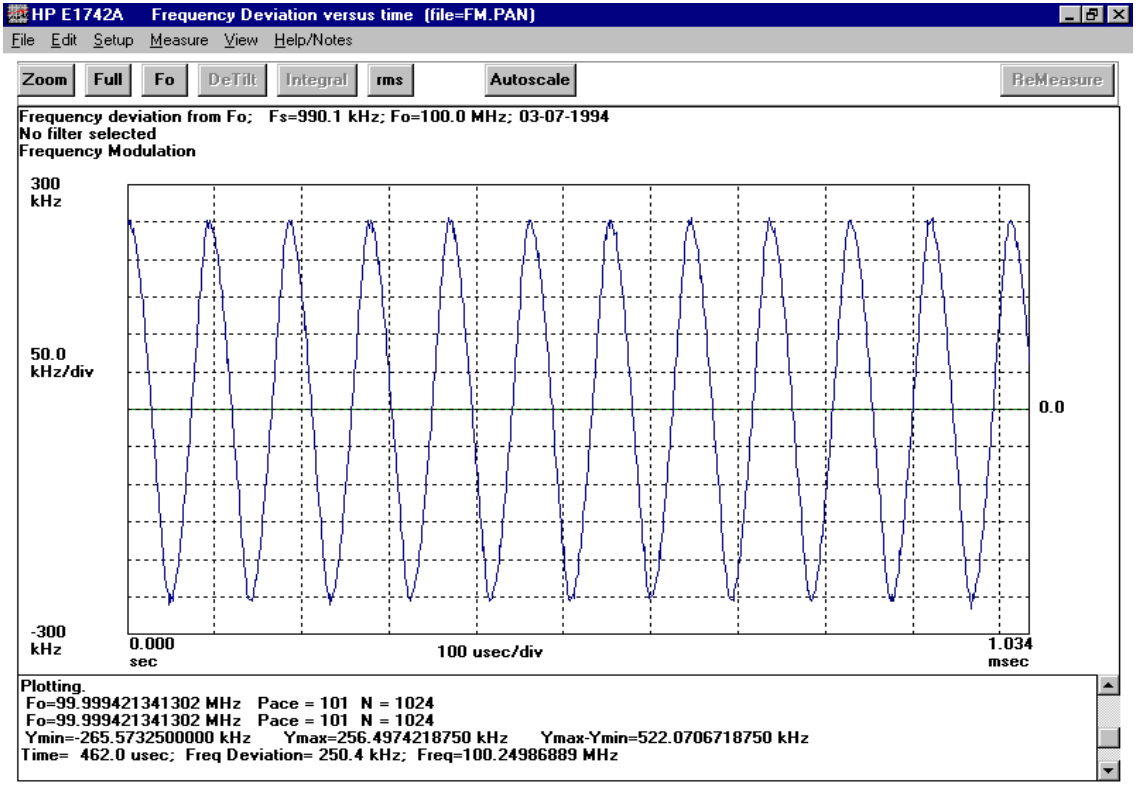
Immediately beneath this information is the graph title as entered on the **Setup>Display Setup** menu, "Frequency Modulation".

The HP E1742A/43A/44A/46A/48A software prompts you for a graph title the first time a measurement has been made. This title is retained for subsequent measurements and can be modified by selecting **Edit>Display Setup**.

The bottom portion of the display is a running log of the instrument status and cursor readouts. This includes information about the data files that have been loaded, the current pacing value in the measurement, the total number of measurement points, etc. In addition, cursor information is also displayed in this box. A scroll bar on the right hand side allows you to view a running list of these results.

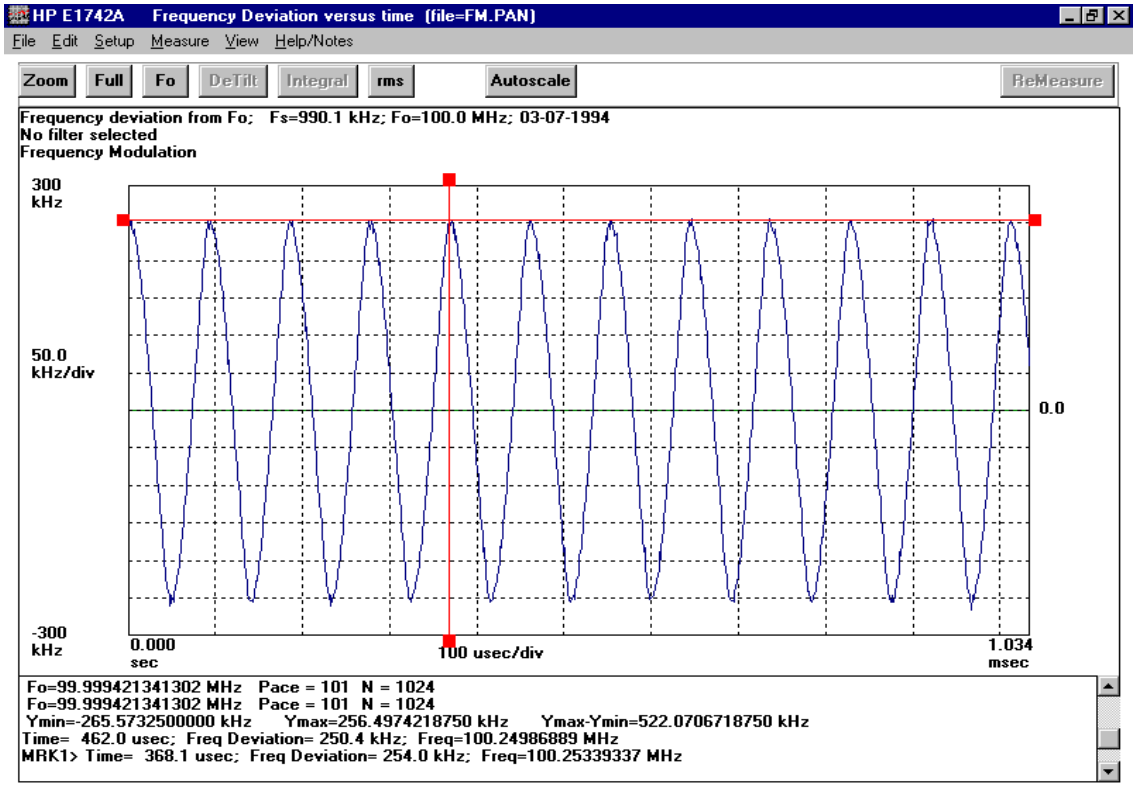
The cursor is a "crosshair" (+) which is controlled by the mouse when it is positioned in the results area of the display. You can retrieve the current mouse position by clicking the left mouse button.

2 Position the cursor on a peak of the sinusoid and click the left button on the mouse.



The last line of the display shows the x value of the cursor (time), the difference between the measured frequency and the carrier frequency Fo (Freq Deviation), and the absolute frequency value (Freq).

You can also display a **marker** (marker 1) on a clicked point by holding the SHIFT key while you click the left mouse button. The same information as above is displayed as MRK1>.

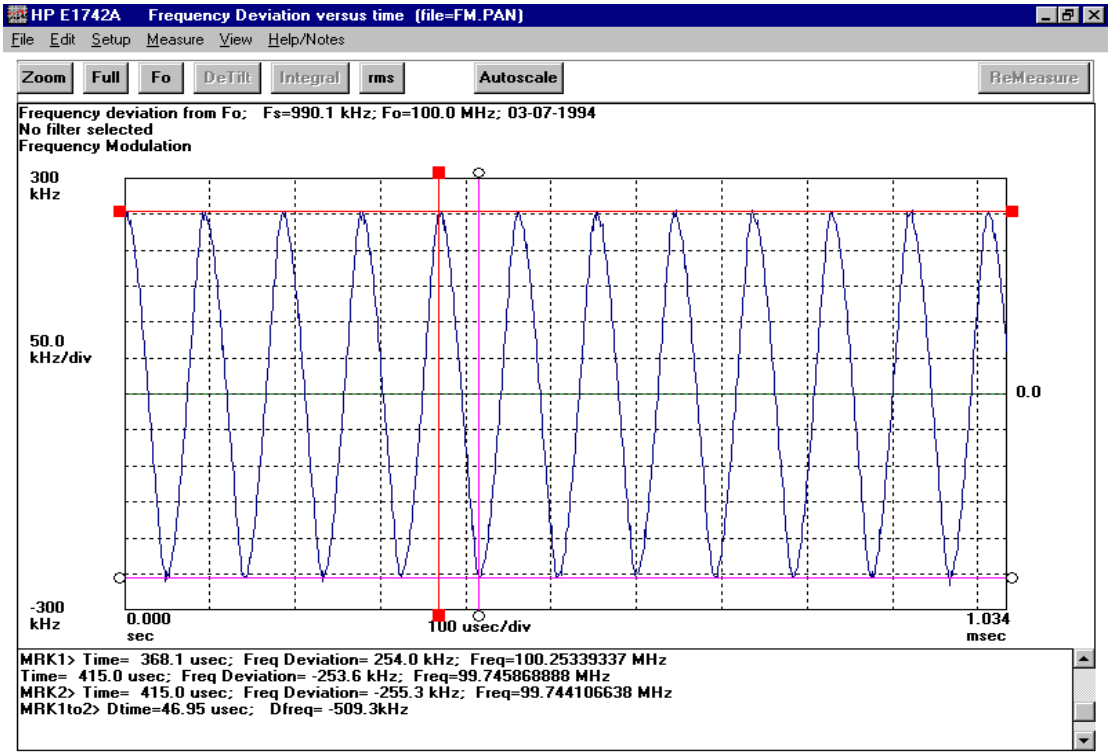


3 Position the cursor at the next peak of the sinusoid and click the left button.

The result log now shows the coordinate values for the new position of the cursor.

Clicking the **right** mouse button will provide both the current cursor position information and the difference between the current position and the last position where the mouse was clicked. Using the **right** mouse button you can move the cursor to successive positions and always display the difference (Dtime, Dfreq, etc.) from the last cursor position.

You can also display the delta **marker** (marker 2) on a clicked point by holding the SHIFT key while clicking the **right** mouse button. The same information as above is displayed as MRK2> and MRK1to2>. To clear a marker, hold down the CONTROL key while clicking on the appropriate mouse button. Both markers may be cleared in one operation by clicking both mouse buttons together.

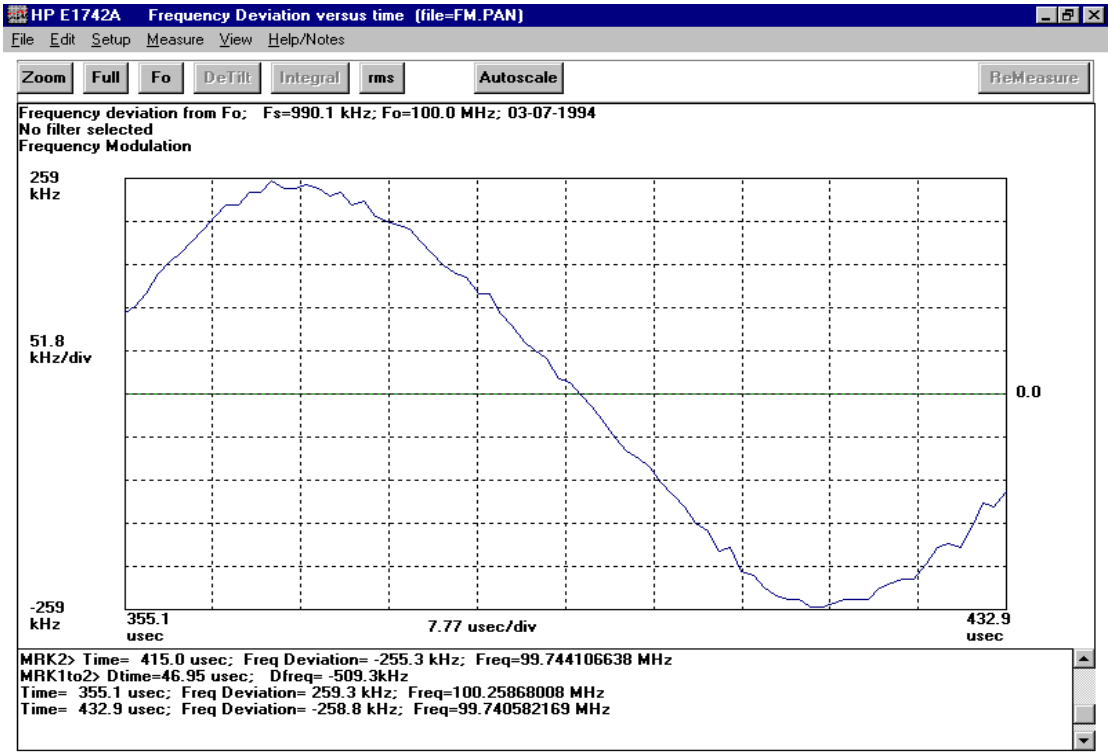


NOTE The cursor position values are the (x,y) position on the graph. The cursor is not tied to measurement data points.

4 You can magnify or zoom in on a particular portion of the waveform by defining the area of interest with the cursor and clicking on the **Zoom** button. Position the cursor at a positive peak of the sinusoid and click the left button. Without releasing the button, drag the cursor to the next

negative peak and release it. The green box defines the zoomed display when the **Zoom** button is clicked.

5 Click the **Zoom** button.



NOTE

You can define the zoom area anywhere in the data display area where the cursor appears as a "+." Valid points are not confined to the grid portion of the data display.

You can achieve greater and greater magnification by repeating the zoom process on successive displays. To rescale the graph to full view, click on the Full or Autoscale buttons.

Printing Results

Select **File>Print Graph**.

This will print the measurement graph area on the currently active Windows printer. You can configure or modify the Windows printer in the Windows Control Panel application. If a printer is not currently active, the buttons will disappear and you will need to exit and restart the HP E174XA software to get them back.

Selecting **File>Print Graph with Log** will print both the measurement graph area and the current results displayed in the log area.

To print the entire log, select **File>Print Log**.

3

Demo Waveforms

In this Chapter

This chapter provides detailed demonstrations using data that was acquired with the HP E1740A TIA and processed using the applications software. The acquired data was saved in files in the “demo” directory. The examples shown can be duplicated with the HP E1742A, HP E1743A, HP E1744A, HP E1746A, or HP E1748A. These data files are “generic” and may not illustrate the specific application for which you purchased the software. The on-line Help file is intended to provide more application specific information.

You will be recalling this measurement data from stored files that are installed during the application software installation process described in Chapter 1. These demonstrations can be performed with or without having the HP E1740A Time Interval Analyzer hardware present.

Demo 1: Voltage-Controlled Oscillator (VCO) Frequency Step Response and Settling

This demonstration shows a VCO whose output is stepped from 9 MHz to 10 MHz. The raw data, or "time stamps" were previously recorded and subsequently saved to a file, along with the measurement setup which processes the time stamps into frequency deviation measurements. The following will be demonstrated:

- Recalling data files from disk
- Using the cursors and markers
- Zooming and scaling
- Frequency deviation measurements
- Settling time measurement
- Frequency overshoot measurement

Start

1 Select **File>Load Setup**... .

2 Open the demo sub directory (c:\hpe174Xa\demo) and click on the file "**vco.stp**."

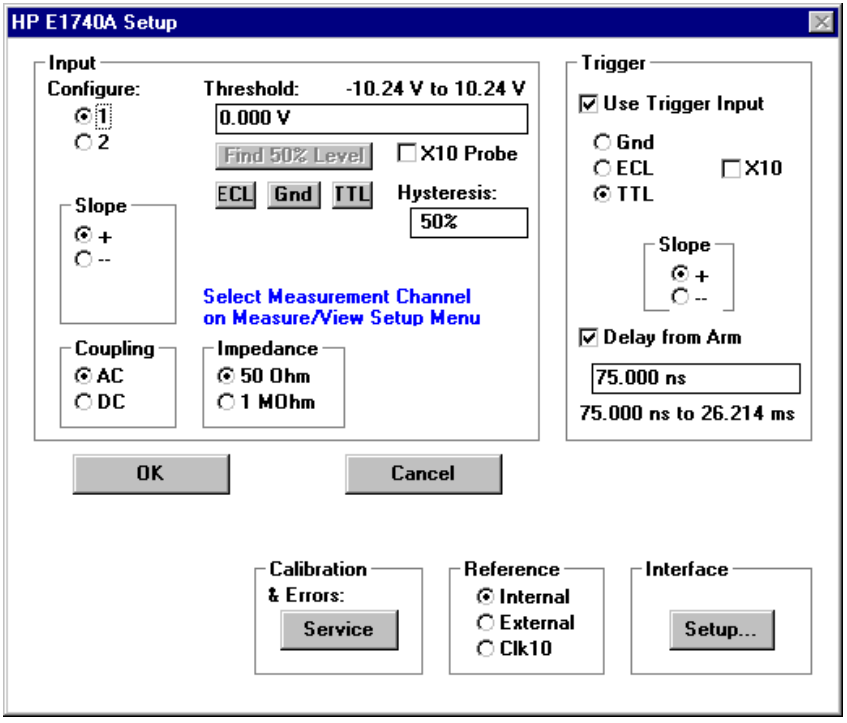
3 Click the **OK** button.

Overview

The VCO under test has a voltage step applied to the input control voltage causing the frequency output to step from 9 MHz to 10 MHz. A trigger signal occurs approximately 116 µsec prior to the voltage step. This trigger signal is connected to the "Trigger" input of the HP E1740A. The VCO output signal is connected to input 1 of the HP E1740A, and is 1 volt pk-pk, centered at 0 volts (no DC offset).

Demo 1: Voltage-Controlled Oscillator (VCO) Frequency Step Response and Settling

1 Select **Setup>Instrument Setup**... to view the HP E1740A setup menu.

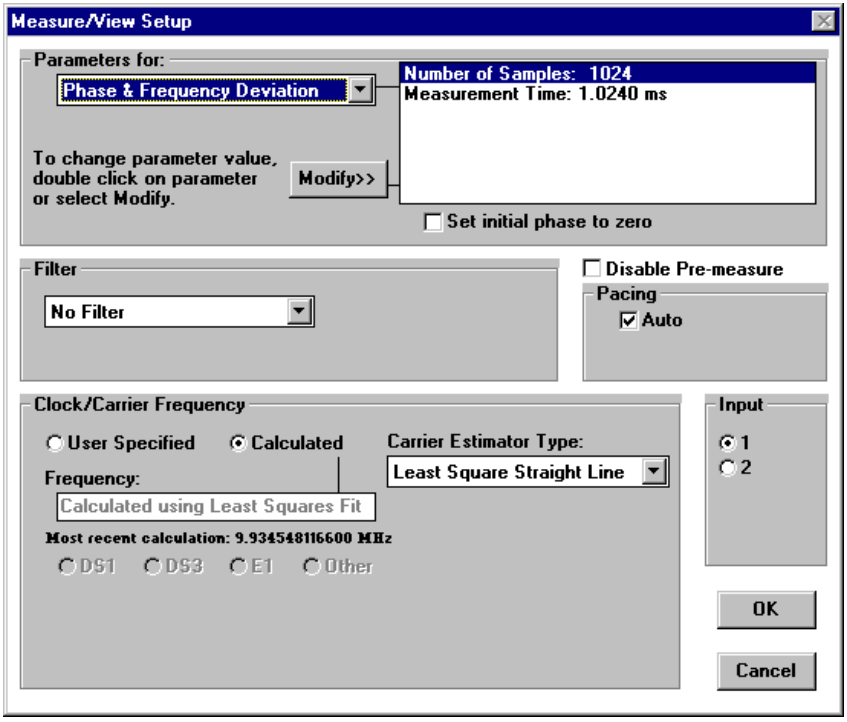


2 This is the **Instrument Setup** menu for the HP E1740A, configured to measure the VCO signal. The input circuitry for inputs 1 and 2 and the trigger input, as well as the delay from trigger are specified on this menu.

Click **Cancel** to close this menu without making changes, and proceed to the next step.

3 Select **Setup>Measure/View Setup**... .

Demo 1: Voltage-Controlled Oscillator (VCO) Frequency Step Response and Settling



This menu lets you set various parameters that apply to the computations performed on the raw timing information from the measurement hardware. You can see the various choices, as the parameters apply, for *Phase & Frequency Deviation* measurement processing in the HP E1742A/46A/48A or *Period, Frequency, TI & Phase* in the HP E1743A/44A. You can see that 1024 measurement samples will be acquired over a period of 1.024 ms. Note that this implies a sample interval of 1 µsec (1.024 msec/1024 samples). About 1 msec of the VCO step will be acquired.

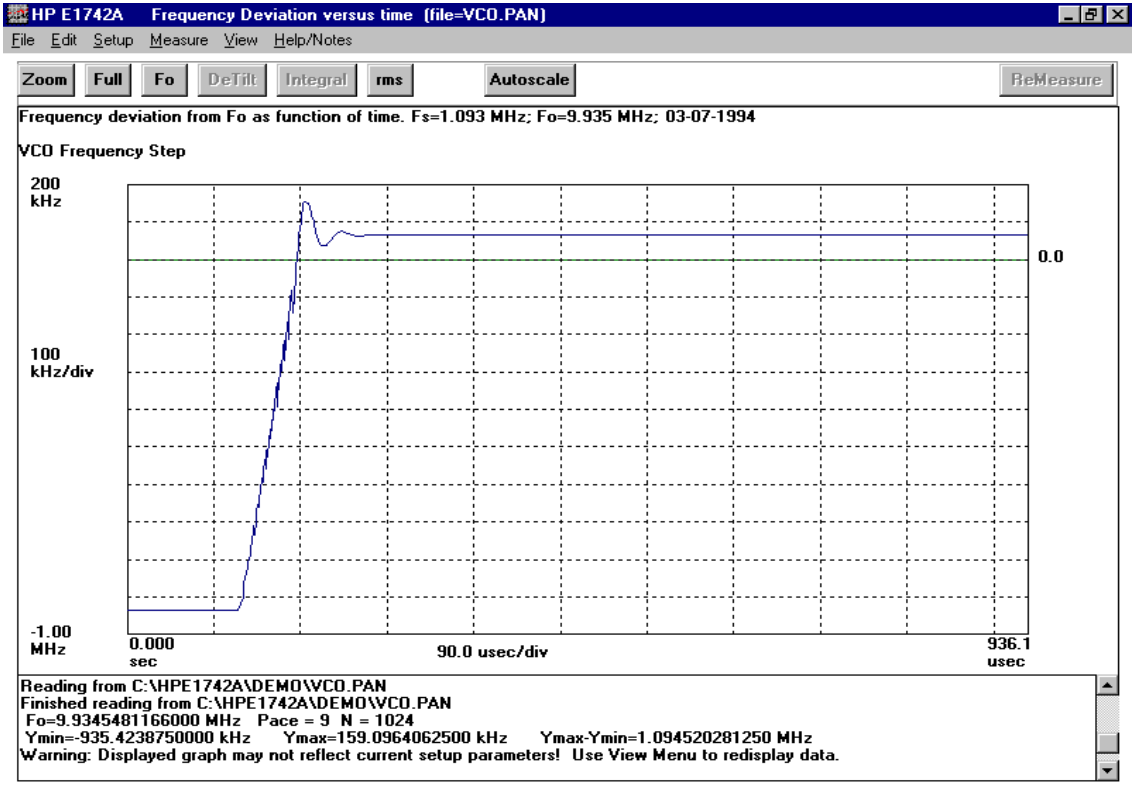
The remainder of this menu is left with default values for this measurement. No filtering will be applied to the data, a least-square fit will be used to determine the reference frequency for frequency deviation measurements (deviation from the reference frequency), pacing will be determined automatically, and input 1 will be used for measurement data.

4 Click on the **Cancel** button to close the **Measure/View Setup** menu.

5 Select **File>Load Data File**... . Open the demo subdirectory (c:\hpe174Xa\demo) and click on the file "**vco.pan**.", and click on **OK**.

This will retrieve the data and display the computed Frequency Deviation vs. time.

Frequency Deviation Results



This is a display of frequency deviation from a constant reference frequency, Fo. The reference shows up in the display as a green line at a value of zero. The Fo computed by the software is displayed in the log at the bottom of the display. This value can be recalled at any time, along with the pacing value and the total number of samples by clicking the **Fo** button on the tool bar.

The step response, frequency overshoot, and settling characteristics can be seen clearly on this display.

Cursors and Markers

The software lets you easily find the (x,y) coordinates of any point on the display (it doesn't have to be a measurement point.) Position the "crosshair" (+) using the mouse at a point of interest, for example the peak of the VCO step waveform, hold the SHIFT key and click the **left** mouse button. The bottom entry in the log area (bottom of the display) will show MRK1>, the x value (time in this case), the y value (frequency deviation from Fo), and the absolute frequency value.

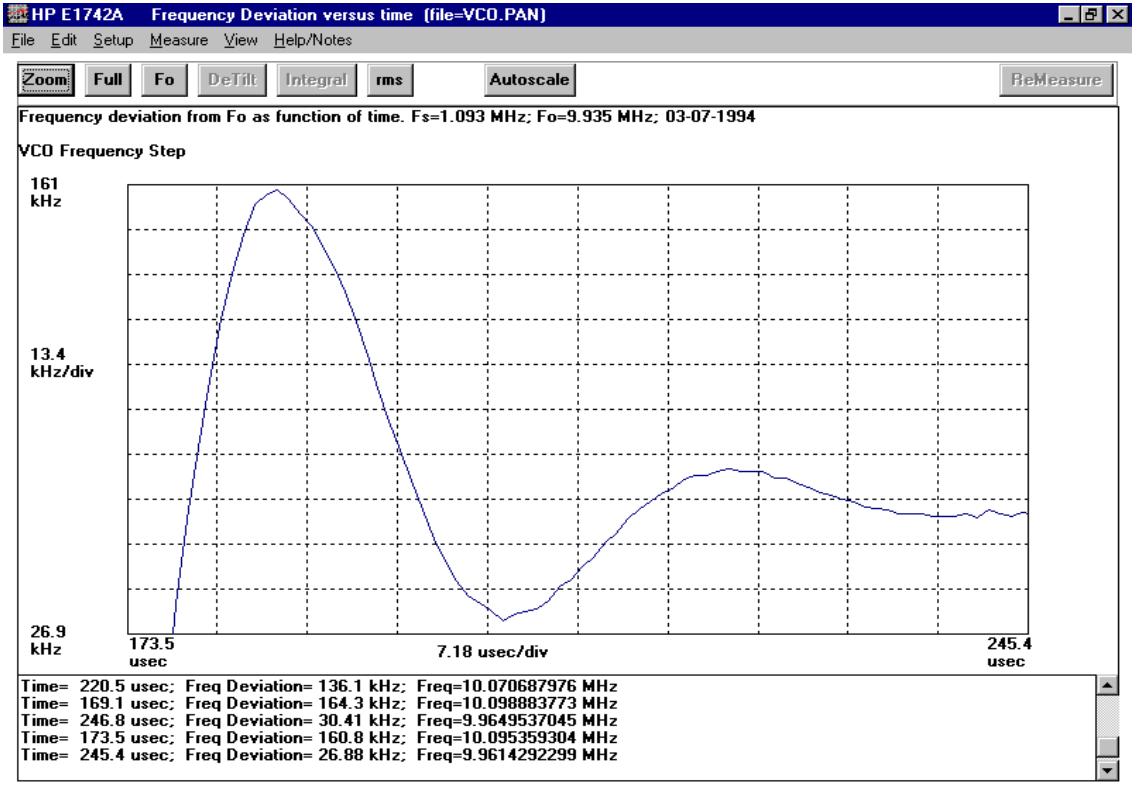
Now move the cursor to a point at the bottom of the "ringing" of the waveform, hold the SHIFT key and click the **right** mouse button. The data log now shows MRK2> and MRK1to2> with the difference in both x (Dtime) and y (Dfreq) from the previous cursor position (D= delta). The peak-to-peak ringing is about 130 kHz. You can continue positioning the cursor at various points and, while holding the SHIFT key, clicking the **right** mouse button; each new log entry will be the x,y difference from the previous cursor position. To clear a marker, hold down the CONTROL key while clicking on the appropriate mouse button. Both markers may be cleared in one operation by clicking both mouse buttons together.

Zooming

Any portion of the data display may be arbitrarily magnified using the zoom feature. You simply define two diagonal corners of a rectangle which will be the new, magnified display.

1 To magnify the peak overshoot and settling of the VCO response, position the cursor just to the left of the overshoot of the waveform. Click and drag the mouse to define the area you wish to magnify as follows. Click the left mouse button (you've just defined the upper left hand corner position of the magnified display) and drag the mouse to a point just to the right of the ringing portion of the waveform, and slightly beneath the 10 MHz frequency level. Release the mouse button. You have defined the lower right hand corner position of the magnified display. The green box outlines the region that will be magnified when you click the "zoom" button.

2 Click the **Zoom** button on the tool bar. The display will "zoom" to the area inside the green zoom box.



NOTE Valid cursor positions include any portion of the display where the cursor appears as a crosshair (+). The data area is not confined to the grid portion of the display. You can actually increase the current display range by clicking in positions off of the grid.

3 To return the scaling to the previous full view, click on the **FULL** button on the toolbar.

Autoscale and Scaling

The application will normally autoscale to the current data set, placing the minimum value near the bottom of the display, and the maximum value near the top of the display. This is particularly useful when you don't know the exact values of the acquired data.

However, at other times, you may be interested in manually fixing the scale so you only view a particular portion of the waveform. For example, you may only be interested in the waveform settling characteristics. Suppose that you are only interested in verifying that the VCO output frequency is within ±10 kHz of 10 MHz, 225 µsec after the trigger signal occurs.

1 To change the reference frequency value, **Fo** to 10 MHz, select **Setup>Measure/View Setup**... .

2 In the **Clock/Carrier Frequency** area of the measurement setup menu, select "User Specified." Enter **10 M** (10 MHz) and press **ENTER**.

3 Click the **OK** button to close the window.

4 Select **View>Frequency Deviation**.

The display will be updated with calculations based on Fo = 10 MHz.

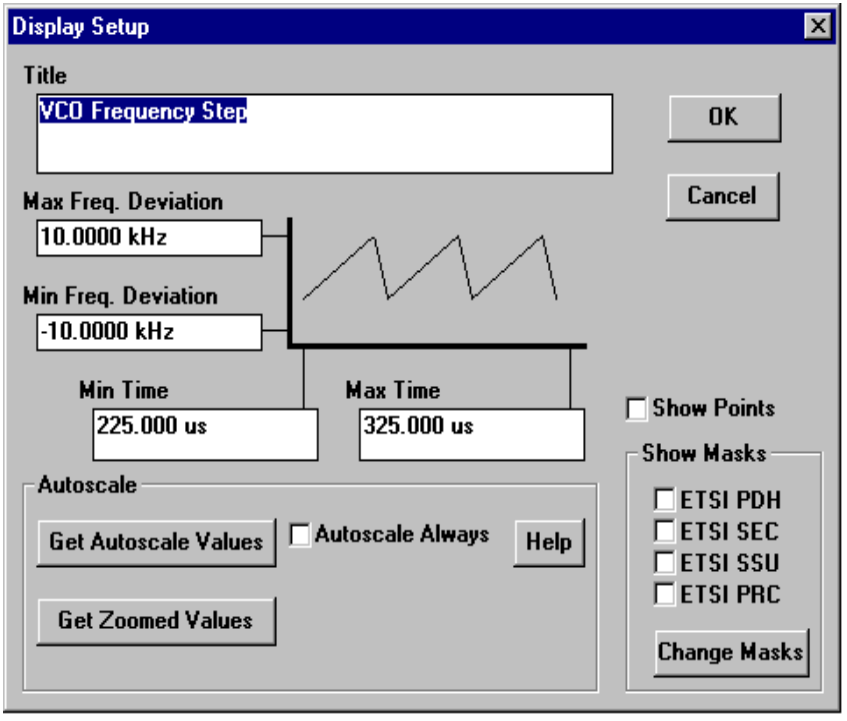
5 To fix the display scale in that region, select **Setup>Display Setup**... .

6 Click on the box **Autoscale Always** to disable this feature.

7 Enter 10 k into the **Max Freq. Deviation** field and press **ENTER**.

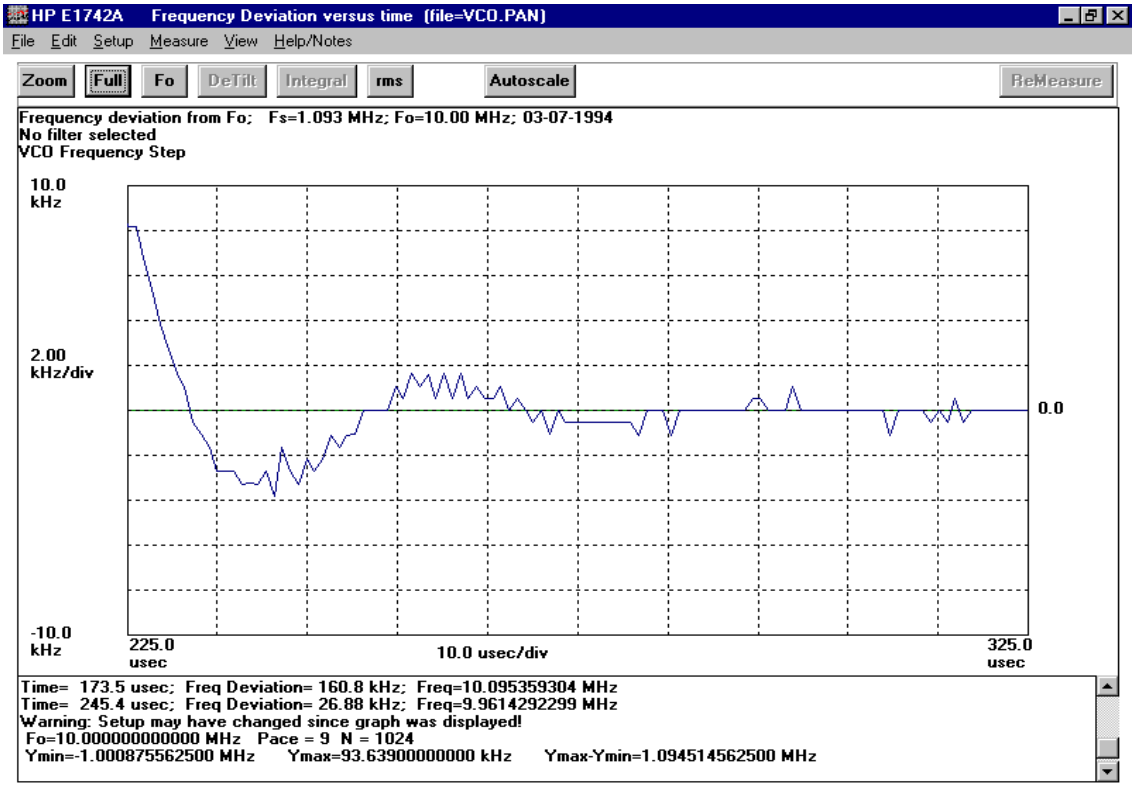
8 Enter –10 k into the **Min Freq. Deviation** field and press **ENTER**.

9 Enter **225µ** and **325µ** into the **Min Time** and **Max Time** fields respectively. Press **ENTER** after each entry. The Display Setup dialog box will appear as follows:



10 Click **OK** to close this window.

The display scale is now fixed at these values. This VCO meets the ± 10 kHz after 225 µsec specification.



11 Select **File>Load Default Setup** and click on **Yes** to return the software to the default setup conditions.

This completes Demo 1.

Demo 2: Phase Modulation Analysis (BPSK)

This demonstration shows the phase modulation analysis capabilities of the TIA, using a BPSK signal (binary phase shift keying). This is a common form of intentional phase modulation for digital communication systems, where a carrier is shifted between two phase states (± 180 degrees). A “1” may be represented by one of the phase states, while a “0” is represented by the other.

The HP E1740A is used to gather timing information from the modulated carrier. This information has been processed as deviation in phase from a carrier and stored in a file. The following features will be demonstrated on this waveform:

- Phase Deviation measurements
- De-Tilt feature
- FFT analysis

Start

1 Select **File>Load Setup**... .

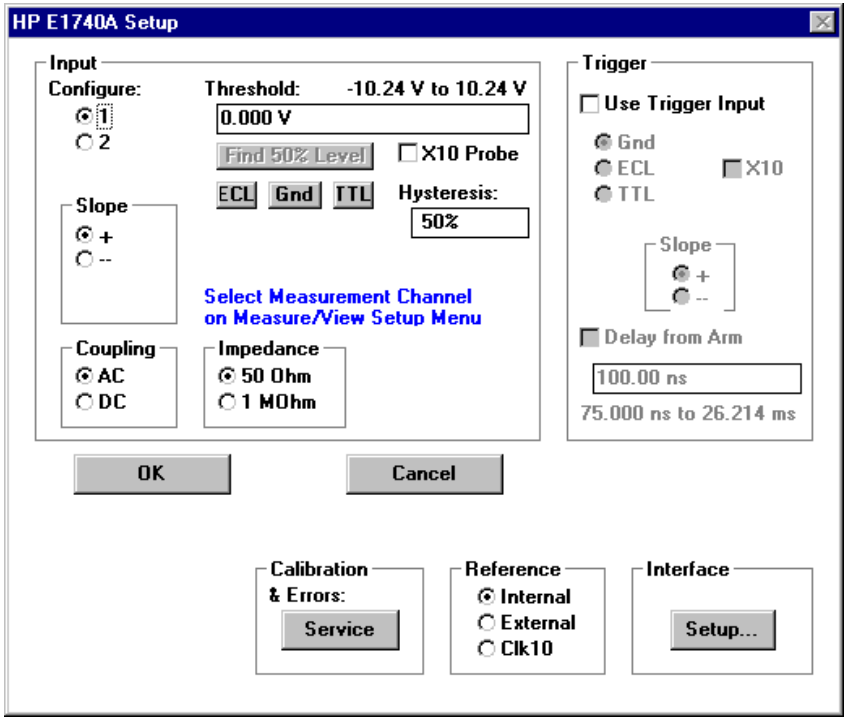
2 Open the demo subdirectory (c:\hpe174Xa\demo) and click on the file “**bpsk.stp**.”

3 Click the **OK** button.

Overview

The signal is a 100 kHz carrier, phase modulated by a 1 kHz square wave. The input signal has an amplitude of 500 mV p-p, and is centered about 0 volts. The signal is connected to input 1 of the HP E1740A.

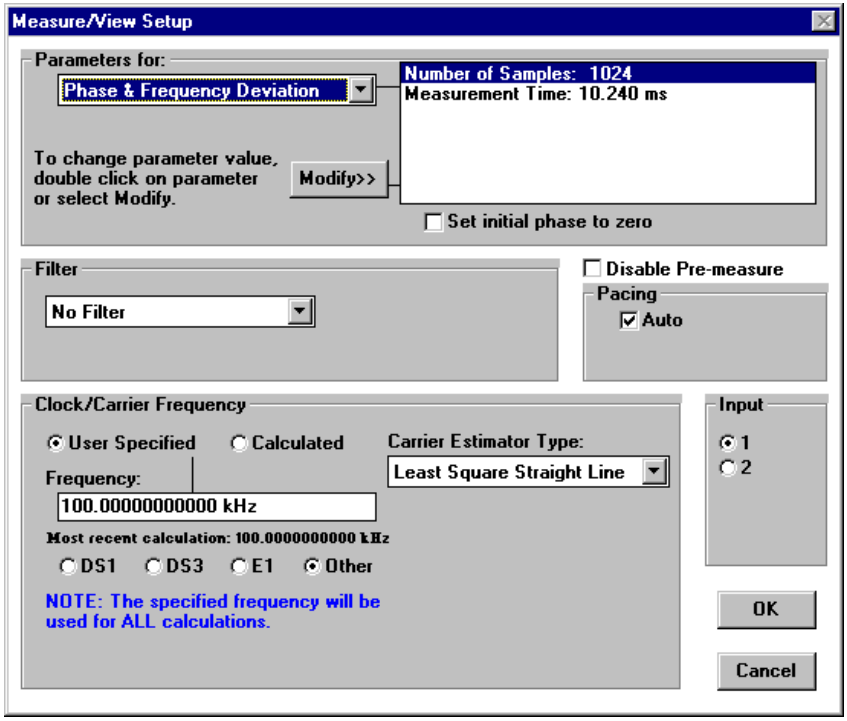
1 Select **Setup>Instrument Setup**... to view the HP E1740A setup menu.



This is the **HP E1740A Setup** menu to configure the instrument to measure the BPSK signal.

2 Click the **Cancel** button to exit this menu without making changes.

3 Select **Setup>Measure/View Setup**... .



Notice that the measurement time for the *Phase & Frequency Deviation* function in the HP E1742A/46A/48A (*Period, Frequency, TI & Phase* function in the HP E1743A/44A) is 10.24 msec. This has been done so the display will show a number of cycles of the 1 kHz modulation. The use of automatic pacing will let the TIA determine the appropriate number of cycles of the 100 kHz carrier to skip, so 10 msec of the signal can be captured and analyzed. A measurement time of 10.24 msec while collecting 1024 samples implies that a sample will be captured every 10 µsec.

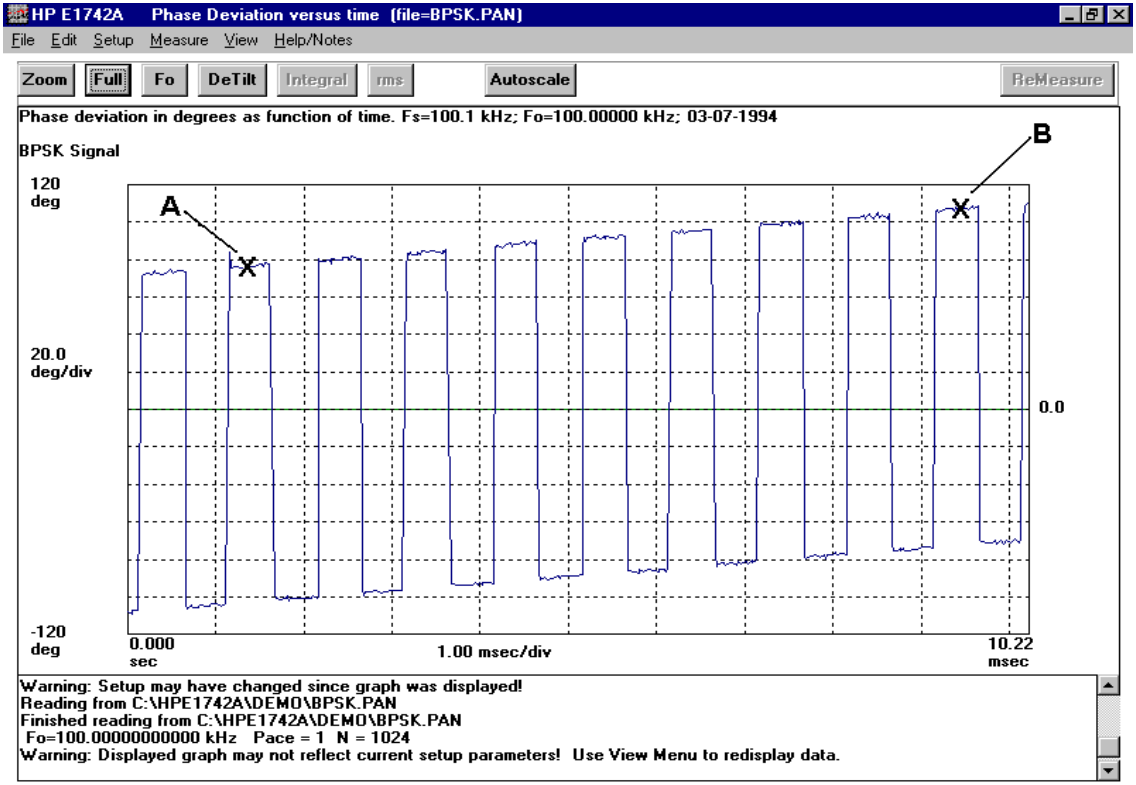
Since phase deviation is a relative measurement, you have the choice of making the first phase measurement zero, or making the average phase deviation zero. The **Set initial phase to zero** box is not checked for this measurement, so the average phase deviation will be zero.

The Carrier Frequency has been entered as a **User Specified** value of 100.0 kHz. The phase deviation measurements will be computed relative to a constant frequency value of 100 kHz.

4 Click on the **Cancel** button to close the **Measure/View Setup** menu.

5 Select **File>Load Data File**... . Open the demo subdirectory (c:\hpe174Xa\demo) and click on the file "**bpsk.pan**." This will retrieve the stored data, and display it as Phase Deviation vs. time.

Phase Deviation Results



This is a display of phase deviation from the constant reference frequency, Fo = 100 kHz. The square wave modulation can easily be seen. Using the cursor (left mouse button) and delta cursor (right mouse button) features, you can easily determine the period of the modulation (1/mod rate), and the peak-to-peak values.

DeTilt

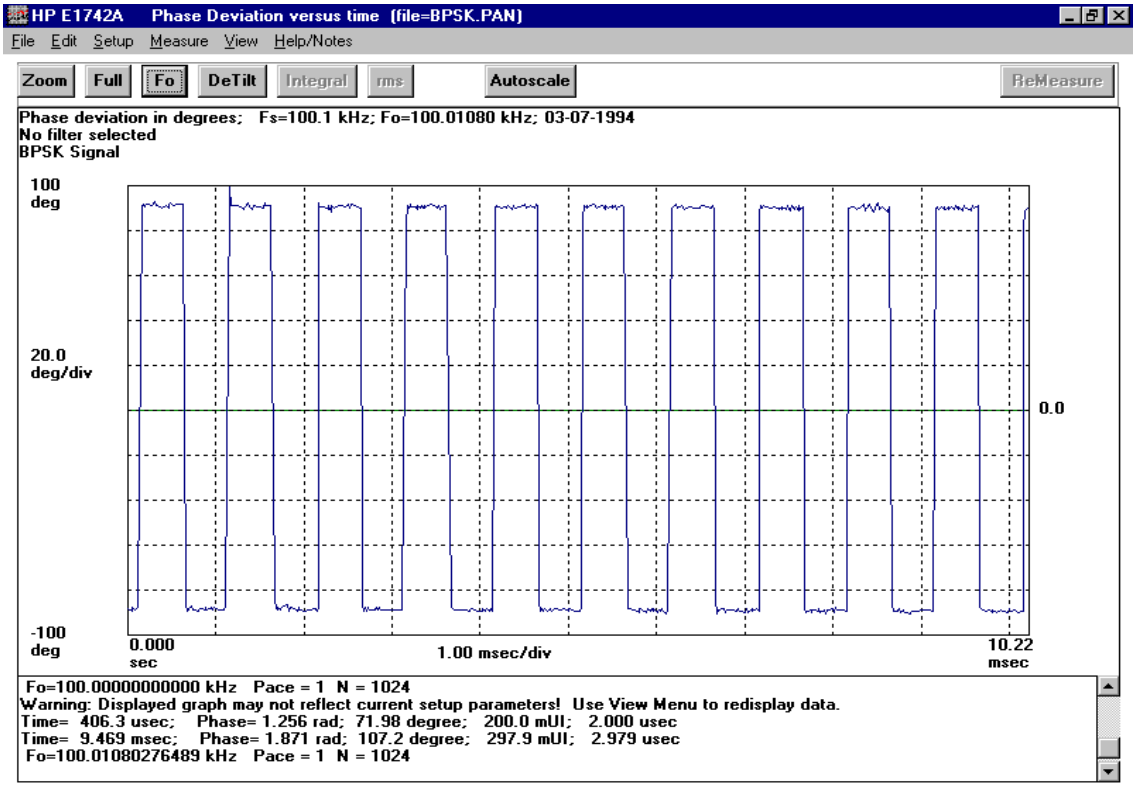
Notice that the modulating signal has a "tilt" over time. This is because the actual carrier is not exactly 100.0 kHz as we specified as the carrier frequency on the **Measure/View Setup** menu. The **DeTilt** feature provides a convenient way to fine tune this value of Fo to get a "flat" display, and determine the precise value of the actual carrier frequency.

1 Position the cursor on one of the "high" phase states near the left side of the plot (point A on the plot shown). Click on the left mouse button.

2 Re-position the cursor on another "high" phase state near the right side of the plot (point B on the plot shown). Click on the left mouse button.

You have now defined two points which *should* be at the same vertical level, but currently are not due to the "tilt" in the waveform.

3 Click on the **DeTilt** button. A warning message will appear indicating that the value of Fo will be modified in the DeTilt process. Click **OK** to acknowledge the warning. After a moment of recalculation, the graph will be re-drawn with a slightly modified value of Fo. The tilt should be removed. Note the new value of Fo (100.01 kHz instead of 100.0 kHz) on the line just below the buttons. You can also verify Fo by clicking on the **Fo** button and viewing the results log at the bottom of the display.



NOTE

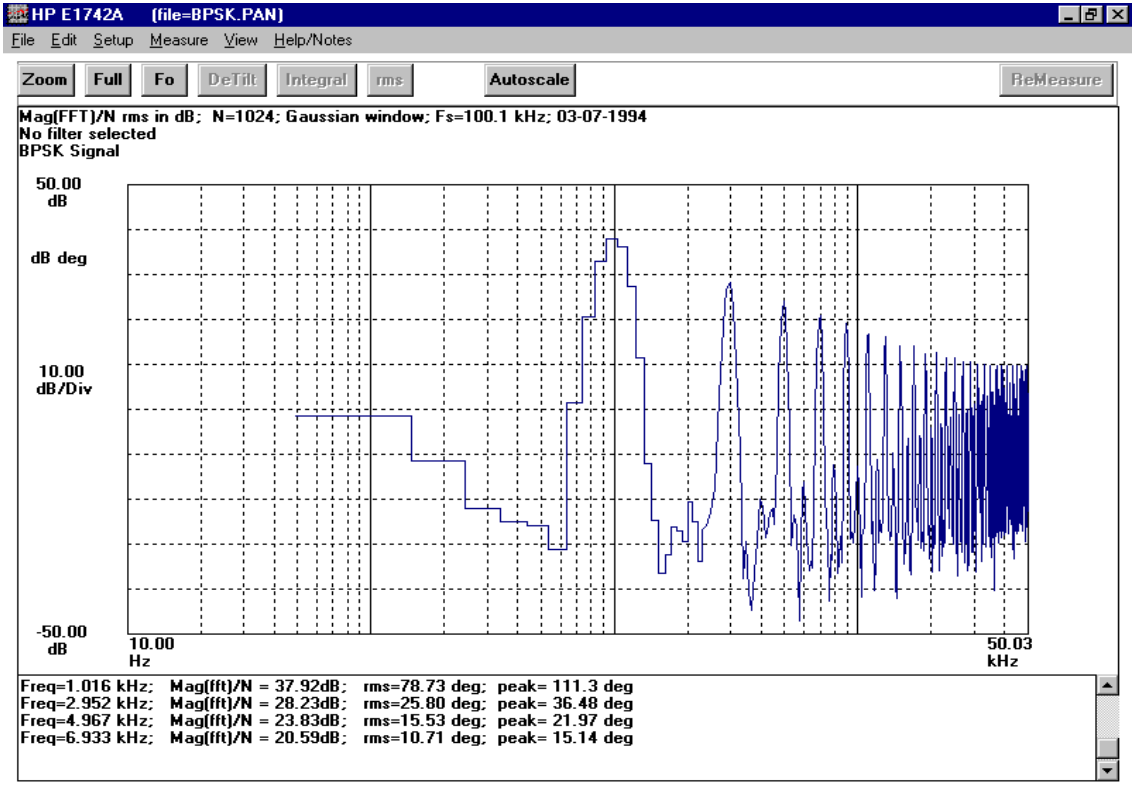
The actual carrier frequency is about 10 Hz greater than the initial value specified for Fo. The DeTilt feature lets you quickly correct for minor discrepancies in Fo.

FFT Analysis

In certain applications it may be useful to study the spectrum of the modulating tone, or perhaps the spectrum of undesired jitter. This analysis can be useful to determine the source of unwanted jitter, or phase noise.

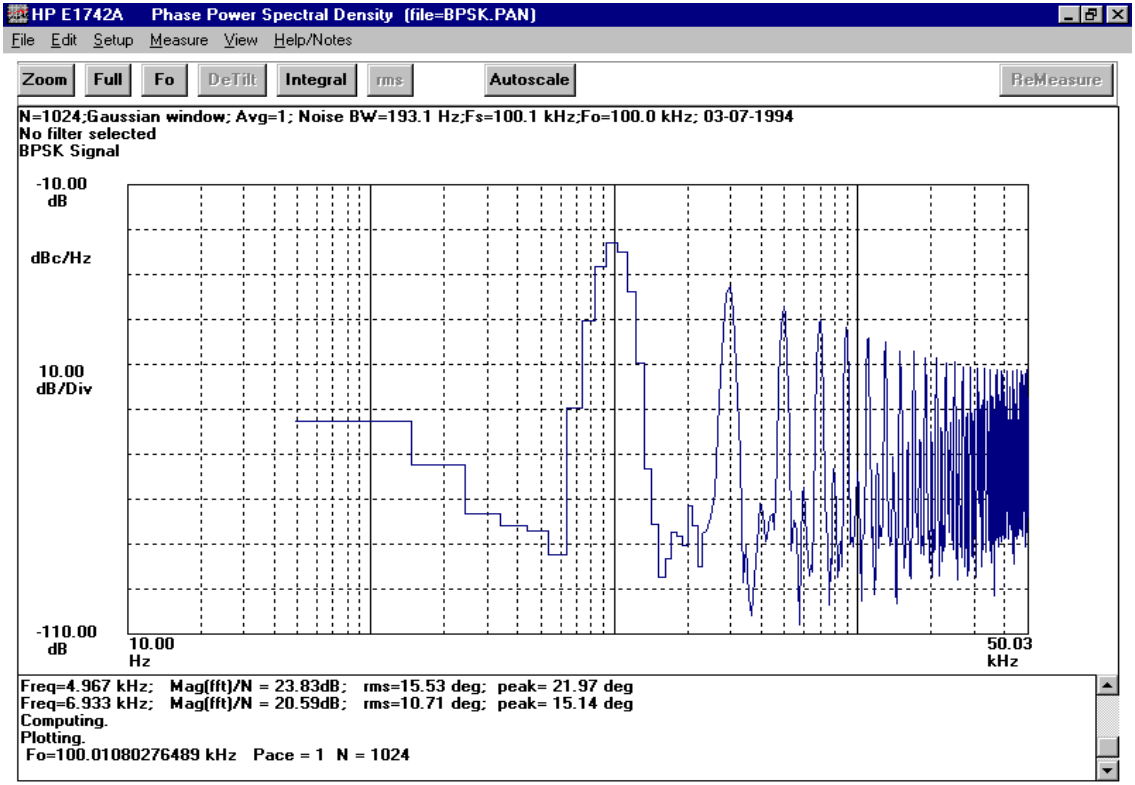
The analysis software offers two methods to view jitter spectrum or phase noise. FFT computations can be made on the currently displayed data (vs. time views). Phase power spectral density calculations can also be performed. This differs from the FFT calculations in that you may also specify a windowing type and sample frequency for the calculations. (See the **Setup>Measure/View Setup** menu.) The theoretical noise floor of the instrument is displayed in addition to the measurement data.

1 Select **View>FFT of current display**.



Using the cursor and clicking on each peak in the spectrum, the characteristic odd harmonics of the square wave phase modulation can be seen. Note that this is not the same view as a spectrum analyzer would display (spectrum of the modulated carrier), but a direct view of the spectral content of the modulation.

2 Select **View>Phase Power Spectral Density**.



This plot is very similar to the FFT. Since it is normalized, the units are in dBc/Hz. Note that the top line of the display shows the noise bandwidth.

This completes Demo 2.

Demo 3: Sharing TIA Data With Other Windows Applications

A powerful feature of Microsoft Windows is the ability to share data and graphics between various applications using “cut and paste” on files. The HP E174XA takes advantage of these features allowing you to easily share TIA data and graphics with other applications such as spreadsheets (Lotus, Excel, etc.), word processors, and other computational packages such as MathCad.

This demonstration will show how easy it is to share the HP E174XA graphics plots and data with a word processor—in this case the Windows “Write” application.

Sharing Graphics

1 Select **File>Load Data File**... .

2 Open the demo sub directory (c:\hpe174Xa\demo) and click on the file “**fm.pan**.”

3 Click the **OK** button.

4 You have retrieved the FM signal you saw in the TIA Tutorial in this guide. Suppose you want to integrate this data with a report or your lab notebook.

5 Select **Edit>Copy Graph**.

You have now copied the active window in the HP E174XA application to the Windows Clipboard. If you want, you can verify the current contents of the clipboard by opening the Clipboard Viewer application in the Accessories group under Programs.

Open the Windows' "WordPad" Program

1 Minimize the TIA application by clicking on the **minimize** ( ) button in the top right corner of the window.

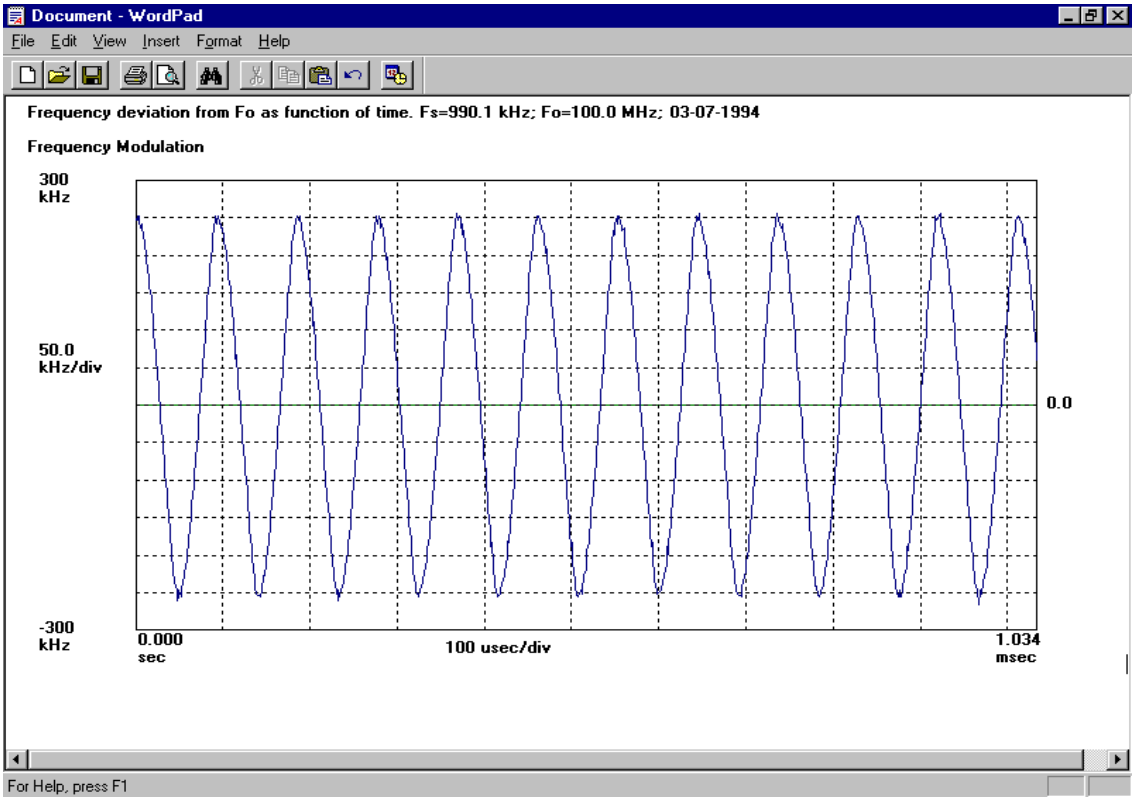
2 In Windows 95, click the **Start** button, select **Programs** group, and select the **Accessories** icon.

3 Double-click on the **WordPad** icon to open this application.

You have now opened the Windows' WordPad word-processor application, and you will see a blank space.

4 Select **Edit>Paste**.

You have just copied the bit mapped graphics from the TIA application to the word processor without a scope camera, printer or plotter as shown in the figure on the following page.



NOTE

Once the FM signal graphics has been copied into WordPad, click the down arrow (↓) or the right arrow (→) to move outside the graphics.

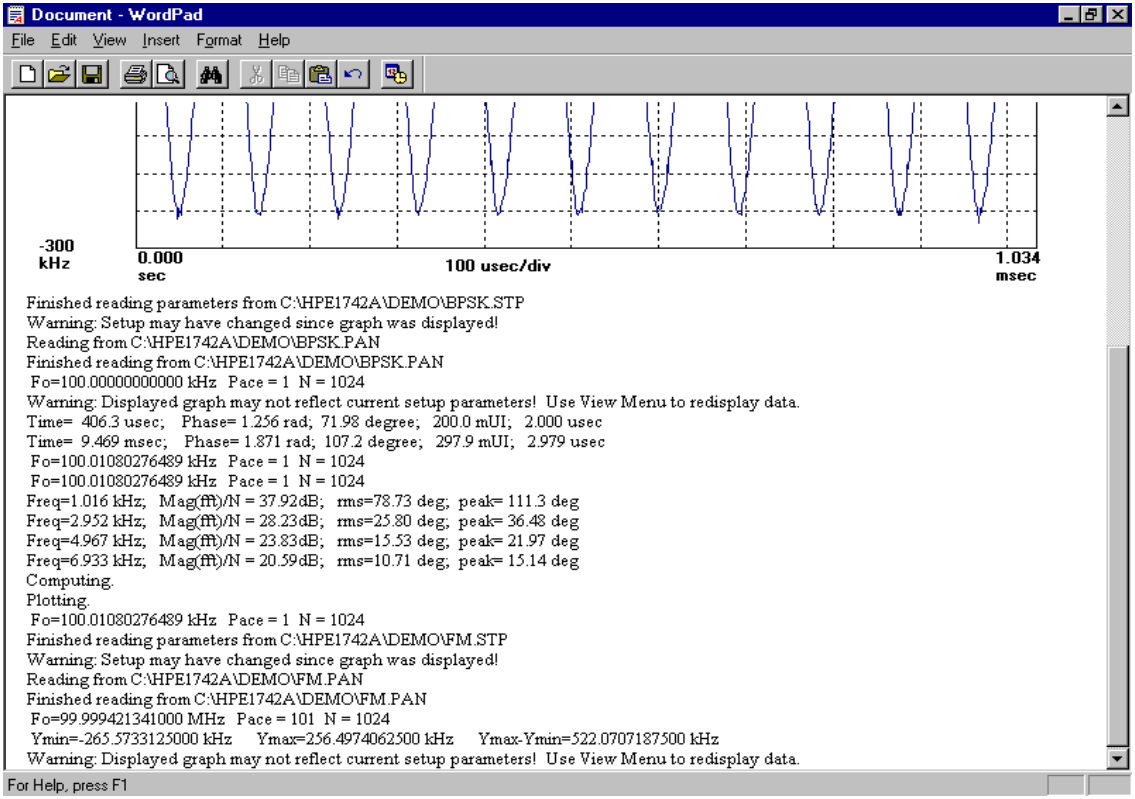
You need to perform the above step to append the log window contents to the FM signal graphics, which is demonstrated in the next procedure (titled “Now Add the Log Information”).

Now Add the Log Information

1. Return to the HP E174XA application by clicking on the HP E174XA icon on the taskbar (or pressing ALT-TAB, or selecting it from the Windows pull-down menu). Select **Edit>Copy Log as Text**. This will copy the entire contents of the logging area of the TIA display as text to the Windows Clipboard.

2. Bring up the WordPad application again.

3. Select **Edit>Paste** in the WordPad application.



You now have both the graphic results, and the entire log window neatly pasted in your report.

NOTE

You may need to modify the font for the logged data. This is easily done in WordPad by highlighting the text to be modified, then going to **Format>Font** and selecting the desired font and size.

Note also that you can directly edit the logging window in the E174XA application by positioning the cursor in the logging window and typing or using basic edit functions from the keyboard. In this way, you can add annotations to the data, or delete undesired information.

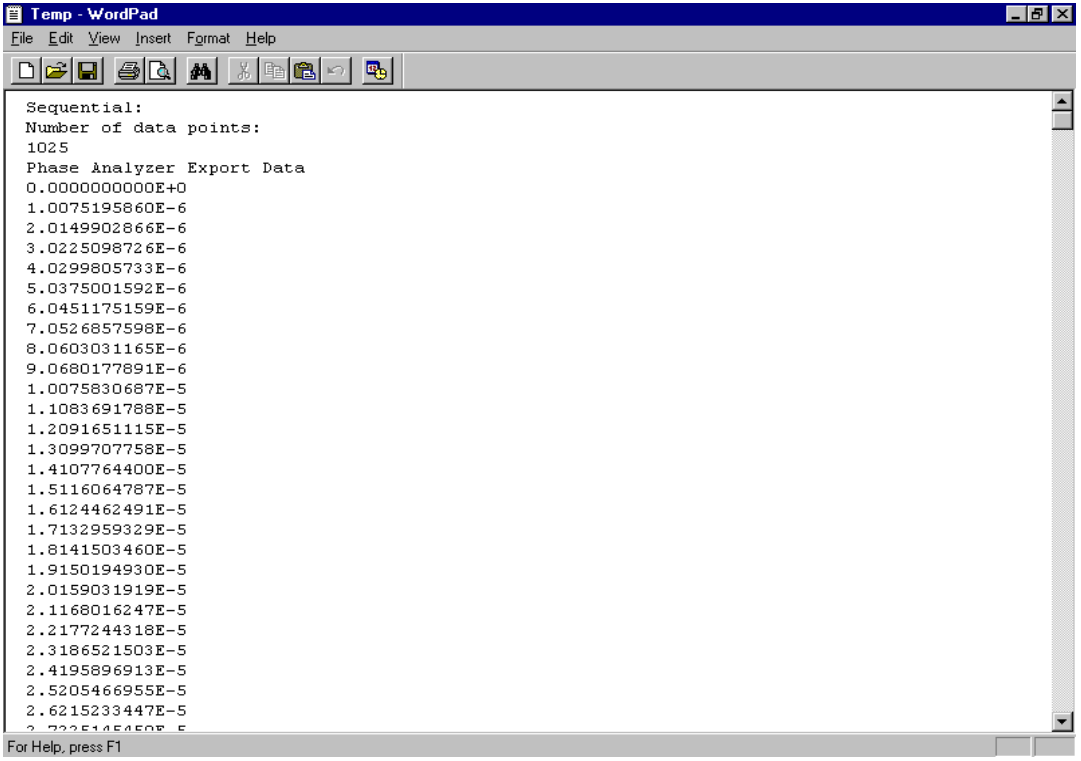
You can copy the entire HP E174XA display using the “Print Screen” key found in the upper right hand corner of most keyboards. Print Screen will copy the entire current display to the Windows clipboard. ALT-Print Screen will copy only the active window to the clipboard.

Sharing Data

1. Return to the HP E174XA application.
2. Select **File>Save Data for Export As**... .
3. Open the demo subdirectory (c:\hpe174Xa\demo).
4. Type the filename "**temp.txt**" and click the **OK** button.

   You have saved the FM data as ASCII text.
5. Return to the Windows WordPad application.
6. Select **File>Open**.

   The Open dialog box appears.
7. Open the directory **c:\hpe174Xa\demo** by selecting the path **c:\hpe174Xa\demo** in the "**Look in:**" field of the Open dialog box.
8. Type the filename "**temp.txt**" in the "**Filename:**" field and click the **Open** button.
9. Click **No** button to answer the question "Save changes to document?".



You now have a list of the raw data measured by the HP E1740A TIA (the "time stamps"—see the Help file for more information). Similarly, you could have imported the data into a spread sheet to perform your own custom analysis of the data.

You can also save the data to a file using the **File>Save Data As**... command. Instead of the time stamps, the data is stored in the format as currently viewed. For instance, if you are viewing a Frequency Deviation display at the time the data is stored, the data is saved as Frequency Deviation vs. Time values. If you are viewing Phase Power Spectral Density display, the data is saved as Frequency vs. Amplitude values.

This completes the Demos.

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Safety Considerations (contd)

WARNING

ANY INTERRUPTION OF THE PROTECTIVE GROUNDING CONDUCTOR (INSIDE OR OUTSIDE THE INSTRUMENT) OR DISCONNECTING THE PROTECTIVE EARTH TERMINAL WILL CAUSE A POTENTIAL SHOCK HAZARD THAT COULD RESULT IN PERSONAL INJURY. (GROUNDING ONE CONDUCTOR OF A TWO CONDUCTOR OUT-LET IS NOT SUFFICIENT PROTECTION.)

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to the earthed pole terminal (neutral) of the power source.

Instructions for adjustments while covers are removed and for servicing are for use by service-trained personnel only. To avoid dangerous electric shock, do not perform such adjustments or servicing unless qualified to do so.

For continued protection against fire, replace the line fuse(s) only with 250V fuse(s) of the same current rating and type (for example, normal blow, time delay).
Do not use repaired fuses or short circuited fuseholders.

Acoustic Noise Emissions

LpA<47 dB at operator position, at normal operation, tested per EN 27779. All data are the results from type test.

Geräuschemission

LpA<47 dB am Arbeits platz, normaler Betrieb, geprüft nach EN 27779.
Die Angagen beruhen auf Ergebnissen von Typenprüfungen.

Manual Part Number E1725-90012

Printed in U.S.A, APRIL 1998